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THORACOPLASTY IN BILATERAL CAVERNOUS TUBERCULOSIS*

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BEFORE I begin with my proper theme, thoracoplasty in bilateral cavernous tuberculosis, I want to express my sincerest thanks for your very kind invitation, which has been a great honor to me, and I am extremely gratified to have been able to accept it. I want to assure you that I very much appreciate standing here and presenting to you in all modesty some results of my limited experience in thoracic surgery.

I am also most thankful, Mr. President, that through the invitation of your Association I have had the opportunity to visit your grand country, to come into touch with the immense medical experience represented by your Association and to enjoy profoundly all the possibilities of medical and general culture which American science offers to her guest. This is the fulfillment of a long-standing wish of mine, as I am perfectly aware that American medicine has achieved the first place among the nations and sets an example to the whole world by her restless and ingenious work, which we intensely admire. For the greatest progress we have seen in the last few years, such as for instance insulin and the liver treatment of pernicious anemia, the world is indebted to America, and there cannot be any doubt that your country has become the admired master and instructor of all medical schools.

I hardly dare to present to you a paper about thoracoplasty in bilateral cavernous tuberculosis, realizing the relatively small amount of material we have in Switzerland. In comparison with your area of work I myself have but the small number of 25 cases of bilateral cavernous tuberculosis treated with total unilateral or partial thoraco-

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plasty, upon which I can base my judgment. Four of those patients were treated with thoracoplasty on one side and thoracoplasty or pneumothorax on the other side. As this bilateral treatment represents a new and debatable branch of thoracic surgery which involves a great deal of the surgeon's responsibility, I hope you will kindly accept my paper as an endeavor toward progress in our interesting as well as necessary antituberculosis work.

We in "distressed old Europe" have worked and will have to work for a number of years under great difficulties. The breakdown of prosperity in all parts of our unlucky continent could not remain without its effect. The social problem became imminent. Without any self-deception we had to find the truth about the present state of efficiency of the different treatments of pulmonary tuberculosis, and we found the following facts: Specific treatment has failed, chemical treatment has not yet passed the period of test, and is still far from the so-called "therapia magna sterilisans." None of these will be able to solve the mechanical problem of more or less large and rigid cavities, about whose vascularization we are not yet quite informed. The dietetic treatment was nothing more than a quickly extinguished flame of deceived hope. The general hygienic methods, as well as the climatic treatment, can never produce a specific influence. Their importance is mainly secondary. The purely conservative view belongs to the past, since we have learned that collapse therapy is in our day the strongest weapon we have at our disposal, and especially that thoracic surgery is bound to continue its development and to increase its possibilities.

I shall speak now of thoracoplasty in bilateral tuberculosis as a procedure that produces an irreparable state of lung collapse but I have some preliminary remarks of essential importance.

First, tuberculosis is always a disease of the whole organism. It is a general infection with all its properties. We find the infectious focus in a toxic and metastatic sense on every occasion in the lymphatic system, where it remains even if it becomes latent. Therefore each cavity must be considered as a metastatic illness. I remember the famous words of Ranke who said: A really isolated tuberculosis can only be observed if the lung is extirpated and placed on the autopsy table.

Furthermore, we have to consider human tuberculosis as an extremely individual problem on a constitutional and biologic basis. The individual is always the product of his origin and of his surroundings. And thus it is absolutely individual. This individuality is emphasized by the consequences of the symbiosis between the bacillus and the human being as soon as the symbiosis passes into illness. We know perfectly well that tuberculosis can be a continual change between periods of inactivity and activity. Therefore all surgical treat-

ment has to adapt itself to the present condition and character of the disease, and we understand that the right time for the surgical intervention depends first of all upon the general state of the body. Surgical intervention can be the immediate *conditio sine qua non* for the patient; it can become advisable and only practicable after a long period of preparation and treatment; finally, it may never become feasible. Sometimes it is very difficult to fix the right time, and only great experience can help to determine the exact moment for intervention.

A third point should be mentioned. While "great surgery" is generally performed on healthy people (except, for instance, cancer or the morbus Basedow) all thoracic anti-tuberculosis surgery has to tackle an organism damaged by a chronically poisoning disease, with the serious consequence of toxic weakness of the heart-vessel system. So it always touches the center of life. At the same time our surgery does not directly attack or eliminate the diseased organ, but it tries to imitate nature by establishing mechanical conditions necessary for fibrotic transformation of the tuberculous tissue.

Thoracic surgery therefore must unavoidably weigh and balance the extent of the whole problem, i.e., the extent of the surgical intervention against the biologic endurance of the individual patient. Thoracic surgery—especially in bilateral cases—is justified only when the tuberculous individual seems to be able-bodied enough to make use of the help given, in a positive sense, and when the intervention does not mean an irreparable damage to the existing local and general power of resistance.

If we regard thoracoplasty essentially as an intervention of biologic importance, we shall understand that the extension of the lung process is only of secondary interest. Practically in no case of lung collapse is it possible to control the totality of the infection. Nor is this necessary, because the purpose of all treatment is the deliverance of the organism from the main focus of specific or secondary intoxication, and this main focus is generally a cavity or system of cavities. By eliminating this source of local and general poisoning we hope that the organism will be able to win the battle.

To see these things in this way it is helpful to mention a mechanical factor which has not been sufficiently considered up to now. Destroyed lung tissue has no respiratory function. Besides, a chronic cavity is often surrounded by a thick and infiltrated parenchyma, and frequently the whole affected part is fastened by large pleural adhesions. This means additional weakening of functional capacities. The destroyed tissue possesses no value for breathing or for the metabolism of gases, but it is pernicious for the affected organism. In observing, for instance, a tuberculous individual suffering from a bilateral cavernous tuberculosis of the upper lobes, but able to lead a more or less normal

life—even if the organic strength is lacking, we have the physiologic proof that the functions of the lungs and heart are sufficiently strong to allow the individual to lead the same life after the removal of these useless parts. One can even say that the elimination of these dangerous parts benefits the general function of the lung-heart complex, because the latter is then freed from the toxically and mechanically paralyzing effects ever produced by a chronic cavernous tuberculosis. We all have observed this often marvelous result by the deliverance of the obstructed heart and thoracic vessels.

For these biologic and mechanical reasons the demand for complete health of the contralateral side is absolutely wrong. This stipulation comes from the opinion that tuberculosis is a disease of a single organ. Without any need it pays no heed to the then sad future of a bilateral cavernous case. This demand is all the more completely unjustified as we have had such very promising experiences with bilateral pneumothorax.

To define clearly the indication for thoracoplasty in bilateral cavernous tuberculosis we must distinguish the different forms of cavities. Tuberculosis can never be strictly subdivided in regard to its character, but it is possible to distinguish two large groups of cavities. For our purpose I do not think it wise or useful to distinguish more than two groups, because the differential diagnosis is difficult and uncertain. I prefer to distinguish strictly between the cavities of secondary and those of tertiary allergy.

The cavity of secondary allergy can be characterized as follows: In the majority of cases this cavity is the result of softened pneumonic infiltration. It is during a certain time elastic, mostly quite round, and is surrounded by an inflamed region. It can disappear spontaneously and quickly, because the wall is composed of soft, fresh tuberculous lung tissue which still maintains elastic capacities. These cavities generally are formed relatively quickly and can disappear with the same astonishing velocity.

The tertiary cavity on the contrary is generally formed much more slowly. It is formed by the softening of one or more parts in a larger infected area, and so it is possible that it slowly enlarges by the conflux of several softened spots. The wall of this cavity becomes more rigid by an indurating transformation, and it is very rare that this kind of cavity will heal spontaneously. Frequently the form of these rigid and sclerotic cavities is not round, but very irregular. The wall represents a thick fibrotic shell which separates the destroyed part from the surrounding tissue and keeps it in a detached position.

Naturally, each of these two groups of cavities corresponds to a certain state of immunity and allows different possibilities of endogenous propagation. We must distinguish between specific affections with open blood and lymphatic vessels and forms with practically no tend-

ency for propagation or, if they tend to propagate, the extension seems possible only by the bronchial route or by direct contact.

The first form belongs to the secondary allergy, the latter to the tertiary allergy.

Of course, also in these so-called tertiary cavities an exudative reaction can be found, and the possibility of any form of endogenous metastasis is not excluded with certainty. Likewise the activity of the process can alter temporarily.

These two states of different local and general allergy can exist at the same time in the same patient. They can change in a reversible sense and can persist one beside the other.

The secondary cavity is the domain of artificial pneumothorax. The tertiary cavity belongs to thoracoplasty.

The young cavity—and I think a cavity can be called young during the first year of its existence—should not be treated by thoracoplasty, for several reasons: (1) It can heal spontaneously. (2) Thoracoplasty may provoke a reaction of the cavity and the surrounding tissue in the form of a specific pneumonia, and frequently this endangers the life of the patient, or it can be followed by formation of a new cavity.

In summary we may say that the operability—especially in bilateral cases—depends upon the following points:

1. The general immunity.
2. The tertiary character of the cavity.
3. The absence of myocarditis, even latent.
4. The relative rigidity of the mediastinum.
5. The capacity of retraction not yet ended.
6. The absence of extrapulmonary foci (bowels, kidneys), except the throat.
7. The general disposition of the patient, in a physical and mental sense.

If these questions can be answered in the positive, the extensiveness of the lung process does not contraindicate a surgical intervention on both lungs, even not a plastic operation on both sides. Only it must be understood that after the surgical treatment there must remain at the functional disposal of the patient at least 40 per cent of healthy lung tissue, in other words the breathing capacity* of the lungs must stay above 1,200 c.c. We have learned from the publications of Liebermeister in Germany that a function of 500 c.c. in cases of bilateral pneumothorax has been sufficient, but I believe that this is exaggerated and that in cases of irreparable lung collapse we have no right to reduce the lung function so much as that.

Before discussing partial thoracoplasty, which enlarges considerably our therapeutic possibilities, I want to say that also a bilateral cav-

*Probably our expression "vital capacity" would better convey Dr. Jessen's meaning. —Editor.

ernous case can be improved by surgical treatment of the more affected lung. Among 140 cases of thoracoplasty observed during the last ten years, 25 of the patients suffered from a cavernous involvement of the so-called better lung. The statistics of these cases show the following:

1. Completely restored, i.e., no bacilli, no fever, no toxic symptoms, 6 patients, or 24 per cent.
2. Practically restored, i.e., rare bacilli, no fever, no toxic symptoms, 9 patients, or 36 per cent.
3. Not improved, 3 patients, or 12 per cent.
4. Operative mortality, 3 patients, or 12 per cent.
5. Late mortality, 4 patients, or 16 per cent.

I consider these results as encouraging. Sixty per cent of these patients undoubtedly condemned to death could be saved; 24 per cent could be completely restored. On the other hand, we failed in 40 per cent because the three patients without benefit from the operation very probably will die of tuberculosis. However, these experiences have shown that surgical treatment depends first of all upon the pathobiologic condition of the patient. We are on the right path when we continue our theoretical and practical studies on the mechanical treatment of bilateral cases either with unilateral or with bilateral collapse therapy. Especially does thoracoplasty include still further possibilities of bilateral treatment, and I feel certain that the perfection of partial thoracoplasty some day will convince those who still doubt.

It was Graf in Germany who proposed to resect practically in entirety the first and second ribs, to take out a small piece from the third to fifth ribs so as to obtain a local but large collapse of the upper part of the lung. There cannot be any doubt that this proposal was a great step forward in the progress of surgical treatment, even if the original idea had to be altered by increasing experience.

At the beginning, this publication of Graf signified a revolution for many of us who were convinced that not only the cavity but also the drainage of the cavity must be affected by the collapse. We were used to observing a healing effect only from a collapse including the hilus. Local intervention resecting five ribs can never produce any effect on the hilus. Therefore I refused this modification of the operation of thoracoplasty and acknowledged its justification only in cases of cavities strictly localized in the top of the lung and without any participation of the surrounding tissue. And these cases are, as we all know, very rare. But in time I changed my opinion, realizing that it is of no use to persist in old wisdom and thus hinder all progress. The really wonderful collapse which can be obtained by this kind of operation forced upon us the question whether it could not be amplified without any danger for the patient.

In the foreground for our consideration was aspiration. In spite of the fact that I had always been convinced that this complication gen-

erally was too much feared, we were facing a new situation because the inferior lobe naturally remained quite open. After the first surgical experiments, made with some timidity, we were more encouraged. Meanwhile we had already seen in a large number of cases—and all authors agree with this experience—that the danger of aspiration from this operation did not increase in comparison with a total thoracoplasty performed in one or two stages. As far as I know, this favorable fact does not depend upon the kind of anesthesia, because all surgeons who operated with general narcosis did not observe an increase of postoperative aspiration. After having done partial thoracoplasty even in patients with 100 c.c. of daily sputum, I am convinced that aspiration ought not to be dreaded. Equally I refuse to do a preliminary phrenicectomy or to make a temporary paralysis of this nerve because such intervention would mean only a reduction of healthy lung tissue which will be useful in the future and which must be especially economized in bilateral cases.

One of the greatest advantages of partial thoracoplasty seems to me to be the fact that it takes good care of the heart as well as of the whole mediastinum. Therefore there is practically no shock after the operation; and, if it affects the heart to a certain degree, this affection is slight and of only temporary significance. It can be said that superior thoracoplasty today is an operation without any risk and danger because the mediastinal organs are not greatly injured. Consequently the mortality has become very low or even zero.

Partial thoracoplasty can be completely individualized in regard to the pathologic condition of each patient and to the extension of the disease, even in bilateral tuberculosis, because the vertical and horizontal extension of resection of ribs can be adapted as necessary. If it is necessary to resect completely the second or the third rib, this intervention can be made in a first-stage operation using an anterior incision following the inferior border of the pectoralis. The resection of these two upper ribs from the cartilage to the axilla is easy in this way. It is a simple operation without any weakening effect on the organism. It can be done easily under local anesthesia and permits the second posterior stage to be performed after a few days. This enlargement of the operation must be considered necessary in all cases of very large cavities, mainly anteriorly localized. But it can be applied only in cases with practically complete rigidity of the mediastinum.

Except in these rare cases partial thoracoplasty can be done generally in one stage. This means a benefit for the patient both physically and from the standpoint of his morale, and it is also of benefit to the cavity because the collapse results equally and irritation of the cavity can probably be avoided. This prognosis at least can be given in cases with a predominant cirrhotic tendency. Otherwise, in cases of a mixed exudative and productive character, a partial collapse can produce

irritation in the part between the collapsed and uncollapsed lung, and this irritation can be followed by the formation of a new cavity. This event would make it necessary to continue the collapse therapy, adding an inferior plastic operation or a phrenicectomy. Therefore, the indications for a bilateral partial thoracoplasty must be determined with extreme exactness.

Considering now the exact indications for partial thoracoplasty, especially for the bilateral operation, we find another great advantage

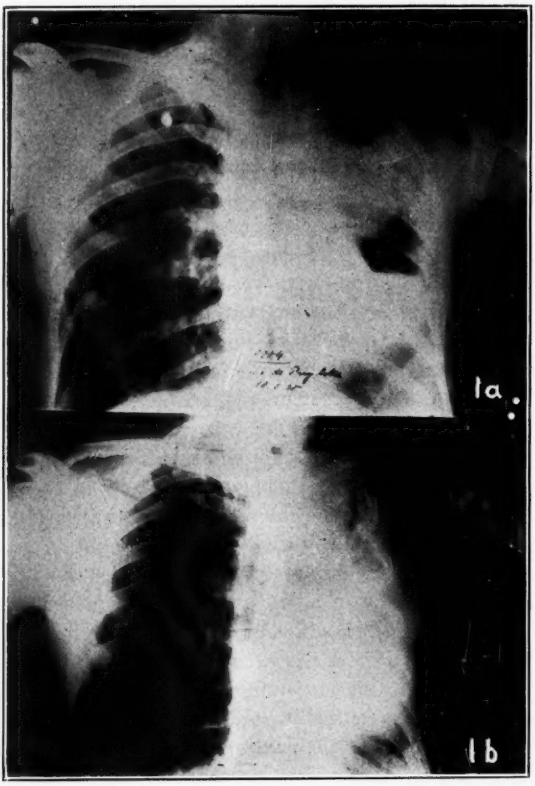

Fig. 1.—J. Nr., 1819, male, aged forty-one years. (*a*) March, 1930. Pneumothorax on the left side, huge cavity in the upper lobe which is absolutely adherent. Phrenicectomy. Little fluid. In the top of the right lung some fibrotic spots (cavity ?). (*b*) Five months after thoracoplasty of the left side. Complete result.

in that it eliminates only affected tissue and saves all the healthy parts of the lung. The total thoracoplasty very often carried with it the inconvenience of immobilizing the whole organ in closing, for instance, a cavity of the upper lobe. In Europe Gravesen and, I am bound to add, myself were the first to show, one independently of the other, that bilateral thoracoplasty is possible.

Finally, partial thoracoplasty makes unnecessary the operation of plombage which I consider an unphysiologic procedure because it is done from a point of view of lung compression and not of lung collapse. Each artificial and more or less violent compression of living tissue produces immediately or in time a reaction which frequently

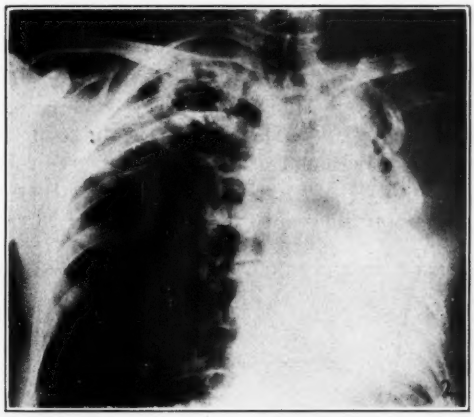

Fig. 2.—Same patient. February, 1933; condition of right lung much worse, huge cavity of second degree of allergy, pericavernous infiltration of the upper lobe. About 30 c.c. sputum daily, tuberculous intoxication and cachexia.

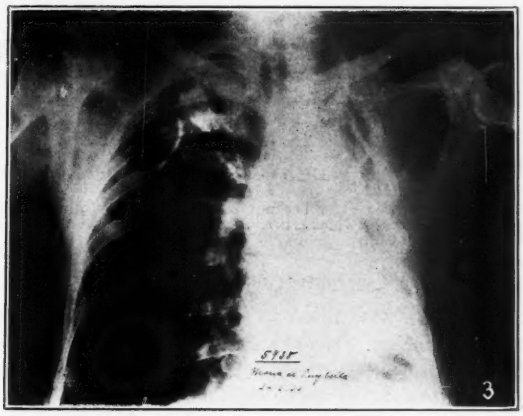

Fig. 3.—Same patient. Three months after having had a pneumothorax on the right side. The reabsorption of the infiltration is satisfactory, the cavity considerably reduced, but no chance of complete healing considering the adhesions.

paralyzes the intended healing effect. Plombage always represents chronic damage to the compressed lung tissue, and the lung, as well as the pleura, does not stand this pressure in the long run. So we are accustomed to see even years later very different results, for instance

a movement of the material, an inflammation of the irritated tissue, the spontaneous expulsion of the material through the wound or, worse, through the lung. Now a partial thoracoplasty produces physiologic collapse because it does not work by lung compression but by loosening and relaxing the fixed organ. And it is only this procedure that follows nature's method which cures tuberculosis by mobilizing the retractive and elastic strength of the lung tissue. Therefore, I am convinced that all plombage has become superfluous because a partial thoracoplasty permits the same careful treatment and eliminates all possibilities of early or late operative complications.

For these reasons we understand why the introduction of partial thoracoplasty in the treatment of cavernous tuberculosis lowered the mortality considerably. My experience has been that the operative as well as the late mortality until now was zero in 26 cases. It is my

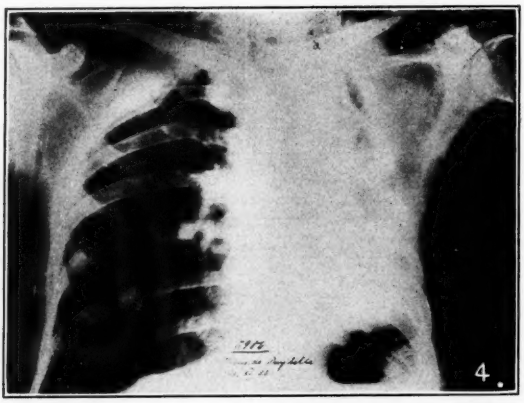

Fig. 4.—Same patient. Six weeks after partial thoracoplasty of the right side (4 ribs), loss of all symptoms.

In May, 1934, eight months after the partial thoracoplasty, an examination showed no sputum, no cough, normal temperature, increase of 8 kg. in weight, no dyspnea, a little cyanosis of nails and lips.

opinion that partial thoracoplasty is the operation of the future and that the indications for it must be established early enough to avoid a total plastic operation. We shall then be able to have a practically inoffensive intervention, and we all can realize how wonderful this progress will be in helping more than by words to vanquish the fear of patients and physicians.

All thoracoplastic treatment now is far enough developed as regards the indications, the technic and the postoperative care that it can be used also in bilateral cases. Face to face with this terrible disease the aim of the treatment is either to obtain a complete victory or only to stop the progress of the disease without considering the final effect. This latter purpose, to change a progressing process into a stationary

one, must be considered in very serious cases as the goal. Sometimes we have observed that the collapse of the more affected lung is sufficient to restore the self-defense of the organism, and we also have seen the spontaneous healing of a cavity of the "healthy lung" after the total collapse of the other.

SUMMARY

Total thoracoplasty is possible in bilateral cavernous tuberculosis if the cavity of the better side belongs to the secondary state of allergy, if the general defense of the organism is not exhausted, and if the patient is willing to risk an eventual artificial collapse of the other lung.

Total thoracoplasty of the more affected lung is also possible if the better lung suffers from a small tertiary cavity which can heal after the restoration of a general immunity either spontaneously or with the help of chemical treatment or by adding a phrenicectomy, a pneumothorax, or even a partial thoracoplasty.

Partial thoracoplasty of both lungs is justified in cases with strictly localized destruction of the top of the lungs belonging to the tertiary state of allergy.

The extreme of bilateral collapse therapy seems to me to be total thoracoplasty on one side and pneumothorax on the other. I have personally observed three cases. A young girl, aged eighteen years, entered the sanatorium in the following state: pneumothorax of the right lung with still open cavity in the upper lobe, total destruction of the whole left upper lobe by an enormous cavity with nearly complete lack of cirrhotic tendency. Expecting certain death I. tried, realizing completely the very bad prognosis, careful surgical treatment of the left lung, conserving at the same time the pneumothorax of the right lung. I performed a thoracoplasty in three stages. Unfortunately the patient died of heart insufficiency a week after the third stage. The second patient was a young lady, aged twenty-three years, suffering from progressing cavernous tuberculosis of the right lung and a small cavity of the left lung. A total thoracoplasty of the right lung in two stages did not restore the patient completely, but enabled her to live for two years after the operation more or less normally. The cavity of the left lung started again to enlarge. I had to make a pneumothorax. This pneumothorax succeeded only partially, but sufficiently to stop the progressive tendency. The patient tolerated this collapse without difficulty, even a collection of fluid could be tolerated during several months without any aspiration. One year later this patient died of intestinal tuberculosis, which became manifest during the last six months of her life.

These two patients were extremely serious cases, because there was no self-defending force and the character of the disease was predominately exudative.

The third case in which the patient had total thoracoplasty on one side and pneumothorax and later partial thoracoplasty on the other I shall show later because it represents a peculiarity in bilateral collapse therapy.

This very rough and at the same time, I am afraid, too concise presentation cannot be finished without mentioning the perhaps most important ally of thoracic surgery. I mean the faith the patient has in the personality of his surgeon. This psychological contact between the patient and the surgeon must be established, and the more the patient follows with perfect faith the psychological authority and therapeutic guidance of his physician the more certain will success crown the combined efforts. We must not forget that to the uninitiated a thoracoplasty means first of all the loss of an organ necessary, in his opinion, for life. He can only see the justification or necessity of this privation if he has faith that health is waiting for him. The psychic power of the surgeon to win and maintain the confidence of his patient is indispensable during the period of preparing the patient, during the surgical treatment itself, and finally during the period of postoperative treatment, which may be long. Such decisive treatment as I have been able to show you just now in the last demonstration is possible only if the psychic power and the suggestive force of the surgeon are complete. The inner willingness of the patient to endure the very exhausting ordeal of thoracic surgery must be predominant, and only in this way is it possible to obtain good results. The wonderful art, surgery, whose followers we are, demands from its pupils that they hide from the patient the bistoury and the pain and that they make him see only the long-wished-for health. Surgery is first of all an act of humanity.

I fully realize that surgical treatment of bilateral cavernous tuberculosis is still in its beginning, but we have already seen results which a few years ago no one would have believed. The battle against the unvanquished bacillus must go on. I am convinced that all thoracic anti-tuberculosis surgery will some day be superfluous. But the human brain has still to work for a long, long time before this aim will be accomplished. Meanwhile we must develop our surgical help. No progress can be made without courage and without being willing to be criticized. No progress can be made without disappointments, but I believe in the efficacy of thoracic surgery.

SIMULTANEOUS BILATERAL ARTIFICIAL PNEUMOTHORAX IN THE TREATMENT OF PULMONARY TUBERCULOSIS

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SIMULTANEOUS bilateral artificial pneumothorax although first introduced some twenty-two years ago (Ascoli, 1912) has not for some reason received on this continent, at least, the recognition it deserves. The scarcity of reports upon the subject in the American literature might lead one to the conclusion that it has found little place in the treatment of pulmonary disease in this country; yet we know that it is in use in many centers for the treatment of tuberculosis. The following series accumulated since 1922 would seem worthy of a report at this time.

The material utilized in this report constitutes the collected experience of the resident staff of Glen Lake Sanatorium over a period of approximately twelve years and includes the material previously presented by us before the twenty-third annual meeting of the National Tuberculosis Association in Indianapolis in May, 1927. The series reviewed includes a total of 120 patients in whom bilateral artificial pneumothorax has been attempted, in 90 of whom bilateral collapse was demonstrable. The remaining 30 have been used as a control group to check the results obtained. The end-results in the control group have been altered somewhat by the subsequent establishment of some other type of collapse therapy.

Thirty-four (28.33 per cent) of these patients were males and 86 (71.66 per cent) females, an excess of females over males of 126 per cent above the average numerical predominance of women over men in the institution (males 44.63 per cent; females 55.31 per cent). A similar disproportion between the sexes has been observed in the unilateral pneumothorax (males 26.3 per cent; females 73.8 per cent) phrenic (males 16.2 per cent; females 83.8 per cent) and thoracoplasty (males 36.8 per cent; females 63.2 per cent) series. The age incidence varied from sixteen to fifty-seven years with 66.6 per cent of the patients in the second decade. Two of the patients presented minimal, 39 moderately advanced, and 78 far advanced tuberculous lesions upon admission, but all were moderately advanced or far advanced at the time of the establishment of the bilateral collapse. Pneumothorax was attempted

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first on the left side in 74 and on the right in 46 patients. The side presenting the most active or most destructive lesion was attempted first in most instances.

The time interval between the attempted pneumothorax on the first and second side varied widely, from a minimum of two days in a few instances to a maximum of six years and ten months. The time interval, of course, varied with the indications for the pneumothorax, being relatively short in the primary bilateral and relatively long in the secondary bilateral group.

INDICATIONS

(1) *Extension to or reactivation of disease in the contralateral lung or failure of an original lesion to improve during unilateral pneumothorax.* This in our opinion constitutes the principal indication for simultaneous bilateral pneumothorax (86 of 120 patients). We do not feel that a slight reactivation of a previously existing lesion or slight extension of new disease should of itself constitute an indication for the immediate institution of bilateral collapse. Certainly constitutional rest and other means should be given a fair trial, for we know that under this regime a considerable number of such lesions will improve. Failure to improve, progression of disease, or the development of cavitation should call for an attempt at bilateral collapse. The establishment of a secondary pneumothorax ordinarily is more satisfactory and offers the patient a better chance of recovery than does giving up the original pneumothorax and subsequently collapsing the second side (alternating pneumothorax).

Contralateral extension of disease presents one of the greatest hazards to the patient suffering from pulmonary tuberculosis either with or without unilateral pneumothorax treatment. This complication occurred in 36.6 per cent of Rist's unilateral pneumothorax series and accounted for 75 per cent of the deaths. The superiority of simultaneous bilateral over alternating pneumothorax with this type of lesion is emphasized again in this same series in which 69 per cent of the patients who developed extension into the contralateral lung did so within one year and 84 per cent within two years, periods of time too short to consistently afford ample assurance of complete healing in the original side if it was originally badly diseased. With bilateral pneumothorax available, the field for unilateral pneumothorax becomes immediately increased because of added confidence in our ability to take care of any contralateral complications.

(2) *Primary bilateral pneumothorax for extensive bilateral disease.* Extensive bilateral upper lobe disease constitutes the second most frequent indication for an attempt at bilateral collapse (21 of 120 patients). In only 13 of these was it technically possible to establish bilateral col-

lapse at all, and in only 8 was it clinically successful. The interval of time between the establishment of the first and second side was relatively low in this group, varying from two days in some to a few weeks in others. Care must be exercised in treating patients in this manner not to establish the collapse so rapidly that it causes distress and dyspnea to the patient. Bilateral tuberculosis of itself does not constitute an indication for bilateral artificial pneumothorax. Certain patients with limited bilateral upper lobe disease with or without cavitation should present ideal indications for this type of treatment. If this procedure were clinically successful, this group should present more individuals for this type of treatment than any other because of the large number of individuals encountered presenting extensive bilateral involvement. The frequent occurrence of an obliterated pleural cavity on one side or the other, in extensive bilateral disease, however, has prevented a wider utilization of this method. Individuals in whom the disease is so extensive that it has already markedly reduced the vital capacity, as well as terminal patients and those who have lost their resistance to tuberculosis, should not be chosen for this type of treatment. Good results cannot be expected if the procedure is instituted merely as the last resort in a desperate attempt to do something for a patient who is already doomed by his tuberculosis. The results obtained by the use of primary bilateral artificial pneumothorax in treating patients with acute exudative bilateral tuberculosis with extensive disease certainly do not warrant the selection of a large number of cases of this type in any series for bilateral collapse.

(3) *Pulmonary hemorrhage.* Pulmonary hemorrhage was the indication for the second pneumothorax in 13 of the 120 cases here reported. The occurrence of pulmonary hemorrhage during unilateral pneumothorax at times raises a serious question as to its site of origin. The primary collapse and the altered position of organs in the chest may greatly confuse the patient in determining the site of the hemorrhage and may give rise to serious doubt in the physician's mind as to the exact source of the bleeding. Failure to control hemorrhage by increasing the original collapse, in case the cavity bearing area is not held out by limiting adhesions, should direct the attention to the contralateral side as the possible source of the difficulty and suggest the use of a second pneumothorax as the solution to the problem if the hemorrhage persists. Collapse of the second lung may control hemorrhage coming from the second side and may possibly be of value if the bleeding is known to be coming from the original lung. Rarely contralateral collapse to such a degree that some mediastinal displacement is produced may add additional compression to the original lung in an adherent region not sufficiently collapsed by increasing the original pneumothorax.

TECHNIC

Bilateral collapse by any method certainly presents additional hazards over the induction of unilateral collapse of the same type. If established slowly and increased gradually, it is tolerated much better than a sudden collapse of lesser extent, the body having the opportunity to adjust itself and to compensate for the changes over a period of time to a degree not possible if induced suddenly. In this series it has been our policy inasmuch as the indications would permit to induce bilateral pneumothorax slowly, proceed cautiously, avoiding distress and dyspnea if such could be done without jeopardizing the patient. An attempt has been made at all times to individualize the treatment of each patient and to govern and control the collapse according to the patient's reaction and fluoroscopic picture rather than by any fixed rule or routine. Early in the collapse of each patient, we have preferred the relatively frequent injections (every two or three days) of moderate amounts of air (150 to 300 c.c.) into the pleural cavity to the injection of larger amounts at infrequent intervals as being physiologically more sound, giving more uniform collapse of the lung and being better tolerated by the patient. Certain patients with relatively normal pleural membranes may absorb air very rapidly, and large amounts of air and more frequent refills may become necessary in order to maintain adequate collapse. This occurs more frequently on the second side probably because of less extensive disease in the lung and more normal visceral and parietal pleura and the more active respiratory excursion. We have preferred to avoid refilling both sides at the same treatment although it has been done on numerous occasions in certain individual patients. We consider it safer, however, to give refills on the two sides on different days for the reasons mentioned above as well as to avoid the possible chance of accidental pneumothorax on the two sides at the same time. Under this plan, dyspnea has been the exception rather than the rule, and the respiratory rate of the patients under bilateral collapse has not been materially above that of their associates under unilateral pneumothorax. The elevation of respiratory rate following any individual refill has rarely exceeded 2 to 4 points except under unusual circumstances (accidental collapse).

Frequent fluoroscopic or plate examination is essential if these patients are to be controlled adequately and their collapse carefully regulated and balanced. Certain individuals of course may be readily worked to a routine schedule which will adequately care for their needs; while others, particularly those requiring extensive collapse in the presence of a flexible mediastinum, must be frequently and thoroughly checked if best results are to be obtained and distress and complications avoided. A note of warning here might be advisable, calling attention to the fact that in a few instances as a result of frequent repeated fluoroscopic

examinations in individuals where such control was absolutely necessary for the proper regulation of the pneumothorax, we have observed a fine irregular mottled skin pigmentation or tanning, later associated with slight telangiectasis as the result of the repeated suberythema x-ray exposure. In none of these patients was an erythema dose of x-ray approached, but in some whose exposures were carefully timed over a period of weeks by stop watch, it was found that they were being maintained over a period of time on approximately a half erythema dose of radiation. Fig. 1 is an example of this type.

We have attempted in each individual patient to govern the amount of pneumothorax by the indications presented, attempting to collapse each lung to a position sufficient to control symptoms and toxemia and

Fig. 1.—J. B., No. 1147, May 15, 1934. Pigmentation of skin in dorsal region from repeated x-ray exposure during fluoroscopic examination. Present for four years.

to close the cavity if possible and at the same time to allow sufficient breathing space for the patient's exercise requirements. In our opinion all patients carrying sufficient bilateral pulmonary tuberculosis to warrant bilateral artificial pneumothorax are sufficiently ill to justify constitutional treatment (bed rest) at the same time. Bed rest is of value not only in adding constitutional treatment for the tuberculosis to the collapse therapy established but also by reducing the patient's respiratory needs it permits the maintenance of a more extensive collapse at a time when this is more necessary. Subsequently with control of the tuberculosis, exercise and even a return to work may be permitted, not infrequently, however, with some reduction of the maximum collapse maintained. Vital capacities below 1,000 c.c., as low as 25 to 30 per cent of the theoretical normal, have been maintained for a considerable

period of time with the patients at rest without discomfort. We have been able, by clinical observation and fluoroscopic control, to regulate adequately the treatment of these patients without resorting to repeated vital capacity readings.

COMPLICATIONS

Patients under bilateral pneumothorax treatment are subject to the same possible complications and dangers as the patients with unilateral collapse. Their relative importance, however, may be markedly increased because of the presence of bilateral collapse and the diminished respiratory reserve of the patient, and potentially some at least may even increase to the point where they may seriously jeopardize the patient's life. Because of this they must be watched for more carefully and followed more closely than with unilateral pneumothorax.

(1) *Accidental pneumothorax.* Accidental pneumothorax, i.e., collapse of the lung due to leakage of air into the pleural cavity through a rent in the visceral pleura produced by the pneumothorax or anesthetic needle, occurs in unilateral pneumothorax practice far more frequently than is generally admitted or recognized. The lung is slightly injured by the anesthetic needle or the pneumothorax needle itself when a first attempt is made to induce pneumothorax and a moderate amount of air leaks from the lung into the pleural cavity. The operator introduces a moderate amount of air and immediately or a day or two later examines the patient's chest under the fluoroscope or x-ray and congratulates himself upon the nice collapse which has been obtained, deluding himself and failing to remember the other patients in whom similar amounts of air had been injected without his being able to visualize the collapse. The patient, as a rule, presents no symptoms. There is rarely a progression of collapse, dyspnea does not ensue, and complications almost never follow. The frequency of its recognition is in almost direct proportion to the care which is exercised in searching for it after the first injection of air is made. Clinically in unilateral pneumothorax it is rarely of much importance, unless perhaps the injury to the lung offers a portal of entry for tubercle bacilli into the pleural cavity to produce an effusion at a later date. Rarely is it necessary to remove air in order to relieve the patient, who usually remains in ignorance of its occurrence. Accidental collapse may also recur on subsequent refills where the lung border remains close to the chest wall and the operator either misjudges its thickness or begins too soon to use a sharp needle for the insufflations. Occasionally it may result from the patient inadvertently coughing, laughing, talking or taking a deep breath during pneumothorax, expanding the lung sufficiently to touch the needle point. These lung injuries present a much more logical explanation for such an increase in lung collapse than does the rupture of a peripheral emphysematous bleb often mentioned as the cause for this difficulty.

Accidental collapse may occur in bilateral artificial pneumothorax both during the induction period and during refills just as readily as during unilateral treatment, but clinically it is of much more importance. (Fig.

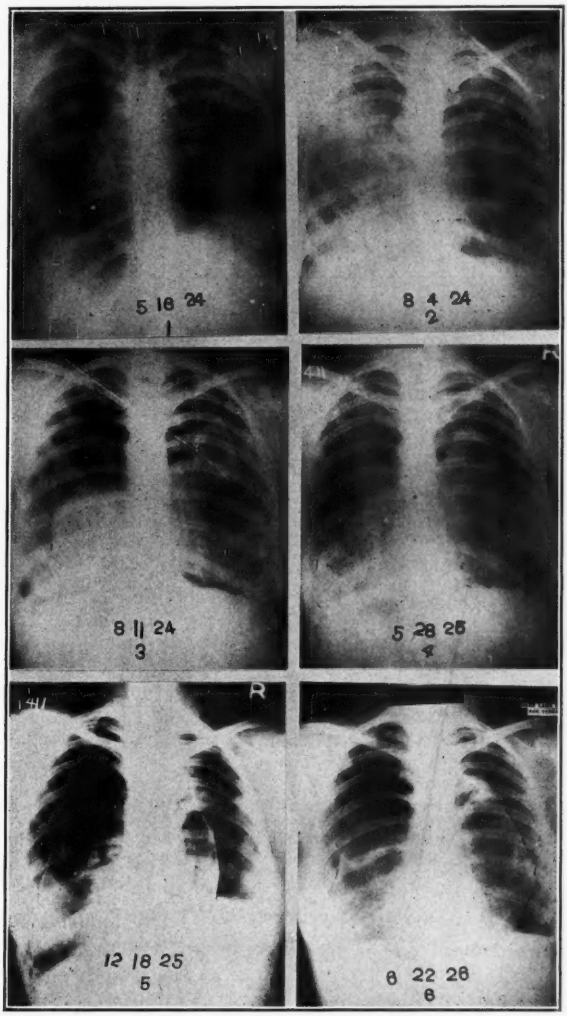


Fig. 2.—G. M., No. 1411.

1. May 16, 1924. Right pulmonary tuberculosis with cavitation.

2. Aug. 4, 1924. Admission. Small right pneumothorax, cavity open. Massive spread of tuberculosis to left lung.

3. Aug. 11, 1924. Bilateral pneumothorax, accidental pneumothorax on the left.

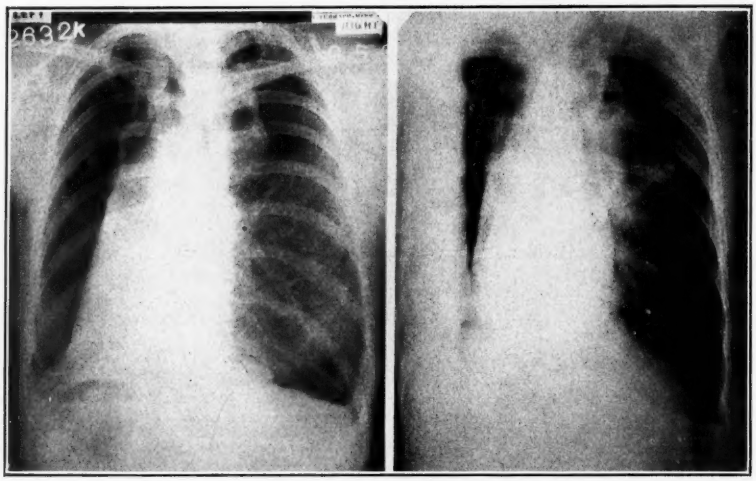
4. May 28, 1925. Bilateral pneumothorax, cavity in the right is not closed.

5. Dec. 18, 1925. Bilateral pneumothorax, cavity on right closed. Right pleural effusion.

6. June 22, 1926. Discharge. Symptom free.

Left pneumothorax discontinued, June, 1930. Right still continued. Patient working over seven years.

2, *3*.) It was recognized in this series on two occasions following the induction of the second pneumothorax and subsequently 16 times in both sides following refills (4 on the first and 12 on the second side). The incidence of this complication may seem somewhat high from the figures above, but it must be remembered that we are constantly looking for this complication and recognizing it and that the series includes several thousand injections of air performed by a number of clinicians and their assistants. It was necessary in 15 instances to remove air in order to relieve the patient. The possibility of such an accident should be kept in mind particularly at the time of the induction of the second pneumothorax, care being taken to be sure that there is sufficient reserve breathing space in the original side to maintain the patient should an



1. *2.*

Fig. 3.—A. W., No. 2632.

1. Sept. 5, 1931. Bilateral pneumothorax with cavities open, right and left, mediastinal hernia from right to left on inspiration.

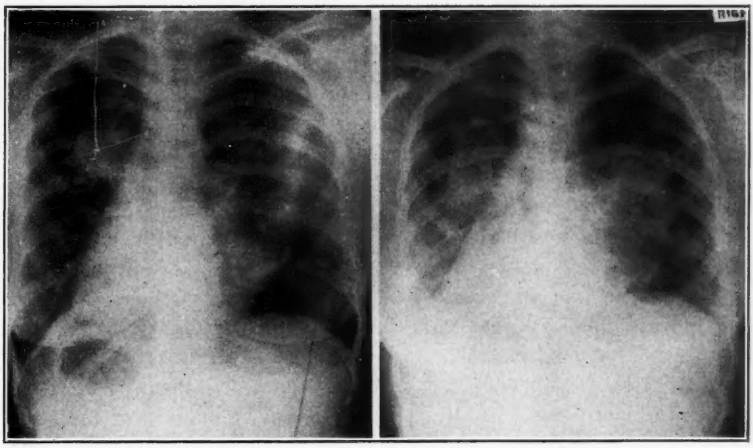
2. Dec. 21, 1931. Bilateral pneumothorax after left intrapleural pneumolysis. Left cavity closed. Left pleural effusion. Patient lying on left side. Mediastinal hernia from left to right, increased on inspiration.

extensive accidental collapse occur. In no instance has it proved of serious import, because it has always been promptly recognized and treated accordingly. In only five instances has it been necessary to remove air more than once in order to relieve the patient, but in two of these, relatively large amounts of air (10,000 to 25,000 c.c. total) were aspirated on a number of occasions before the leakage ceased and the pneumothorax could be continued.

(2) *Spontaneous pneumothorax.* Occasionally during bilateral pneumothorax as during unilateral collapse, a true spontaneous pneumothorax due to rupture of lung or cavity into the pleural space has

occurred. In no instance in this series has this happened in a violent manner or produced dangerous symptoms. In one patient only the development of an empyema with secondary infection and the subsequent demonstration of a bronchial fistula proved the spontaneous origin of the difficulty.

(3) *Overcollapse of the lung.* Occasionally in our ambition to control symptoms and to close the cavity, the collapse of the lung has been pushed to such an extent that it gave the patient distress or dyspnea, severe enough on two occasions to warrant aspiration of air to afford relief. The more usual indication, however, for removal of air aside from accidental pneumothorax, has been the onset of pleuritis with effusion with increased intrapleural pressure causing the distress, intercurrent



1. *2.*

Fig. 4.—L. R., No. 3676.

1. Sept. 29, 1930. Inspiration. Bilateral pneumothorax, mediastinal hernia from right to left.

2. Sept. 29, 1930. Expiration. Bilateral pneumothorax, mediastinal hernia from right to left. The hernia is larger on expiration.

respiratory infection or some extrathoracic cause such as gastrointestinal flatulence or intraabdominal surgery.

(4) *Mediastinal hernia.* Mediastinal hernia (anterior mediastinal pneumatocele) is a well-recognized complication of artificial pneumothorax but is not of serious consequence during unilateral collapse, being more of a nuisance than a detriment, though at times seriously interfering with the establishment of adequate collapse until the mediastinum has become stabilized. During unilateral collapse it bulges into the contralateral side to its greatest degree during the expiratory phase of respiration and becomes reduced in size or disappears entirely with inspiration. These also occur during bilateral collapse and may at times

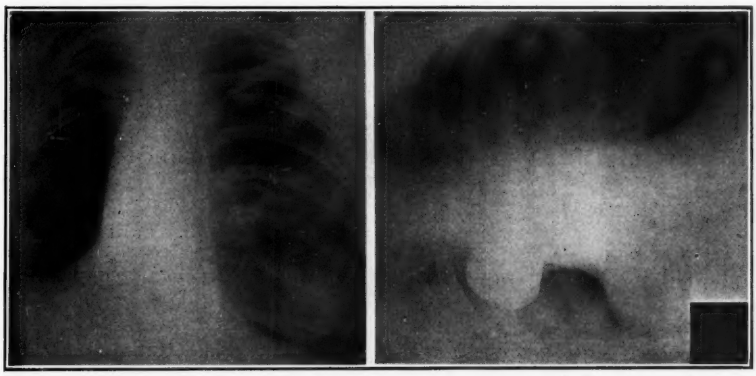
be seen extending from right to left or left to right depending upon the local conditions. Fourteen patients in this series have presented this complication to a considerable degree, 12 of them from right to left and 2 from left to right, including 2 which were observed first in one direction and then in the other. Unlike the hernias appearing in unilateral pneumothorax, those seen during bilateral collapse usually attain their maximum size during the inspiratory phase (14); though this is not always true (Fig. 3), for 2 patients have been observed in which the hernia behaved in just the opposite manner at a subsequent date, attaining its maximum size during the expiratory phase. (Fig. 4.) Thirteen of these hernias bulged from the second to the first side and three from the first to the second side, including the two which reversed direction. These two which subsequently reversed direction and appeared at their maximum during the expiratory phase both extended from the first to the second side during the bilateral pneumothorax, but one extended from left to right and the other from right to left.

The convexity of these hernias will always be found bulging toward the side which carries the highest negative pressure at the moment when and in the position in which the hernia is observed. These hernial protrusions are usually readily recognizable on the fluoroscopic screen but may easily be overlooked because of their delicate outline unless careful search is made. Unlike those occurring in unilateral pneumothorax, the majority of these observed during bilateral collapse are less likely to be overlooked on x-ray films, because of their average increase in size on inspiration and consequent visualization on ordinary inspiratory films as routinely taken. A hernia is, of course, merely a visual demonstration of an attempt on the part of the body to equalize the pressures within the two pleural cavities by a deviation or bulging of the semiflexible partition at its weakest point, the anterior weak spot of Nitsch in the upper anterior mediastinum. Frequent fluoroscopic examinations are necessary in the presence of such complications in order to balance the pneumothoraces on the two sides. Occasionally these bulgings are overlooked or ignored, and concentration is placed too strongly upon the collapse of one lung and under such conditions they may increase markedly in size or even develop into a burrowing mediastinal hernia. An example of this (to be published in a separate report) progressed from right to left to such a degree that it performed an almost complete extrapleural pneumolysis upon the left side. Eventually air was injected into the right pleural cavity and its hernial extension to the left through needle puncture sites in both axillary regions.

The hernial sac may be nicely outlined, if there be free fluid present in the pleural cavity from which it arises, by rotation of the patient into such a position that it becomes filled with pleural fluid. It may also be visualized by the injection of some radiopaque material such as

skiodan or neo iopax into the pleural cavity with the patient in such a position that it runs immediately into the hernial sac. (Fig. 5.) These substances not only outline the pocket but, because they are hypertonic solutions, irritate the local pleura in the same manner as the hypertonic saline or gomenol advocated by some authors to produce a stiffening of this mediastinal partition. They are absorbed rapidly from the pleural cavity and excreted promptly through the kidneys.

No consideration of mediastinal hernia and its occurrence during bilateral collapse could be complete without some consideration of the relative pressures of the two pleural cavities. Theoretically in the normal individual, the pressure in one pleural cavity should closely simulate that in its mate on the other side. Practically, this is not necessarily true, the resistance of the mediastinum and its contents to displacement



1. *2.*

Fig. 5.—R. R., No. 2779.

1. Feb. 10, 1933. Bilateral pneumothorax, left phrenic neurectomy. Mediastinal hernia right to left on inspiration, indicated by arrow as a clear semicircular area.

2. Feb. 23, 1933. The hernia is outlined with skiodan injected into the right pleural cavity with the patient lying on the left side.

presenting the factor of difference between the two pressures. We have repeatedly noticed a relatively wide range of pressure readings in the two pleural cavities without present or antecedent evidence of inflammatory disease to cause fixation of this structure. Adhesions within the pleural cavity, thickening of the pleura, etc., of course, may alter this picture widely and permit good negative pressures on one side and moderately positive pressures on the contralateral side. In an occasional patient bilateral pneumothorax has been maintained with high positive pressures on both sides. On the other hand, some patients show pressures which are strikingly similar on the two sides, and in such instances there is quite likely to be a thin, flexible mediastinal partition, particularly in the upper anterior portion.

One factor which is not sufficiently borne in mind in artificial pneumothorax work is the variation of intrapleural pressures with position. Pressure readings taken with the patient lying on the contralateral side may not give us any accurate idea of what the pressures may be in the same pleural cavity with the patient in dorsal, prone or upright position. Shifting of the mediastinum, elevation or lowering of the diaphragm, abdominal distention, etc., may alter the pressure readings considerably. Likewise a comparison of the pressure readings in the two pleural cavities taken on subsequent days or several hours apart with the patient lying on opposite sides at the time of separate injections of air may also be misleading. A true estimation of intrapleural pressures and their relation to each other can be obtained only by simultaneous readings on the two sides, using two manometers. This has been done in a few instances in this series in order to check the relation of the pressures to the occurrence of mediastinal hernia and to furnish the information necessary for its control. But it is not to be recommended, particularly if the lung is close to the chest wall on either side, because of the danger of traumatizing the lung.

(5) *Pleural effusion.* Pleural effusions in this series have occurred 19 times in the original and 9 in the contralateral or second pleural space, in 17 patients simultaneously on both sides and in 5 patients alternately on both sides. As a rule these have been small and clear, and have not seriously interfered with the collapse at the time. Occasionally, because of rapid formation, they have been the cause of increased intrapleural pressure to the point where the patient suffered distress sufficient to indicate the removal of air or fluid or both (14 patients). Rarely repeated aspirations have been necessary. These effusions have at times interfered somewhat with the routine handling of these patients, necessitating more frequent fluoroscopic observation and more careful control of the pneumothorax. A few have been followed by an adhesive pleuritis which subsequently caused a partial loss of pulmonary collapse. They have in a few instances proved beneficial by producing a stabilization, of a very flexible mediastinum, thereby reducing difficulties of balancing the double pneumothorax.

(6) *Purulent effusion (empyema—tuberculous and nontuberculous).* Purulent effusions have occurred in 12 patients in this series, in two of them on both sides, and all save one of these occurred as a later development of a previously clear effusion. Ten of these were proved tuberculous, one nontuberculous (staphylococcus), and one a mixed infection empyema with tubercle bacilli and secondary organisms. One occurred approximately three months following an intrapleural pneumolysis, with a section of several large adhesions necessary to close a large pulmonary cavity. Eight months later, however, the patient developed a tuberculous purulent effusion on the second side without any intrapleural manip-

ulation. The possibility of transfer of this infection through the thin mediastinal pleura to the second pleural space must be considered in this instance as the patient possessed a mediastinal hernia of considerable degree at the time of the development of her original empyema. Seven of these have subsequently cleared under constitutional treatment, aspiration and saline irrigations with or without loss or discontinuation of the pneumothorax. One patient developed a pure staphylococcus empyema following a nontuberculous bronchopneumonia. This cleared following repeated aspirations and irrigations with acriflavine solution and expansion of the lung to the chest wall. Another patient developed a very virulent mixed infection empyema, which did not respond to conservative treatment, following spontaneous pneumothorax with bronchial fistula. She subsequently died some two and one-half weeks following extrapleural thoracoplasty from a pneumonia produced by the aspiration of material through her bronchial fistula into the contralateral lung. Two patients with bilateral tuberculous empyema subsequently cleared the process on both sides. One of these died subsequently from a progression of her pulmonary tuberculosis. The other will probably die in the near future of progressive amyloid disease. The occurrence of an empyema during the course of bilateral pneumothorax is of course a serious complication, but not necessarily a fatal one. It should be treated along the same lines as indicated for a similar condition during unilateral pneumothorax.

OTHER PROCEDURES DURING BILATERAL PNEUMOTHORAX

A consideration of other things which have been done or have happened during bilateral pneumothorax is of interest not only as a demonstration of the amount of pulmonary collapse which it is possible to maintain by various combinations of treatment, but as an indication of the stability of the individuals with bilateral collapse and their ability to withstand certain intercurrent accidents and manipulations. Two individuals in this series have not only carried a bilateral pneumothorax of considerable proportions but at the same time have had the diaphragm paralyzed by phrenic nerve operation prior to the establishment of the second pneumothorax. In neither of these individuals was any difficulty encountered; although in both cases extensive collapse was maintained—in one a 90 per cent pneumothorax, plus the diaphragmatic paralysis on one side and a 20 per cent collapse on the other—in the second patient a 40 per cent collapse on one side and a 30 per cent pneumothorax collapse plus diaphragmatic paralysis on the opposite side. In the first patient the phrenic nerve paralysis of a permanent type was induced to supplement the original pneumothorax in order to obtain closure of the cavity. A temporary phrenic nerve interruption was done in the second patient while carrying unilateral

pneumothorax because of contralateral extension of the disease and was followed by temporary improvement. The second pneumothorax was induced while the diaphragm was still paralyzed, because of subsequent extension of the disease.

Intrapleural pneumolysis by the so-called closed two cannula method has been performed on three individuals in this group without undue difficulty. In the presence of a flexible mediastinum the cannulas were sealed by means of rubber glove fingers tied around the flanged portion of the cannula and the instrument introduced through a small slit in the rubber membrane giving a relatively tight joint which markedly reduced but did not entirely eliminate air leakage. Intrapleural pressures sufficient to avoid distress to the patient and prevent mediastinal displacement were maintained during the procedure by aspiration of air from the pleural cavity through one cannula provided with an aspirating channel.

Two patients in this series, while carrying bilateral pneumothorax, were subjected to upper stage thoracoplasty under local infiltration anesthesia, one for an apical cavity uncollapsed by artificial pneumothorax, the other for a tuberculous empyema with secondary infection. The surgical collapse itself was well tolerated and did not distress either patient. Both of these patients died subsequently, however, one on the fifth postoperative day from aspiration of material from the cavity into the contralateral lung and the other on the sixteenth postoperative day from pneumonia following the aspiration of pus through a bronchial fistula. These deaths occurred a number of years ago, and as we see it now both were probably avoidable.

One patient included in this series had the second pneumothorax of her bilateral collapse established during the sixth month of pregnancy because of contralateral extension of disease with pulmonary hemorrhage. Her progress was uneventful until approximately one week before the calculated date of delivery when a small pulmonary hemorrhage occurred from the second side, which could not be controlled by increasing this pneumothorax, the upper portion of the lung being held out by broad adhesions. She was delivered of a living child by cesarean section performed under spinal anesthesia without difficulty and is alive and in good condition today, more than three years after the operation. Two patients with bilateral pneumothorax have undergone laparotomies for acute appendicitis under spinal anesthesia and one under local infiltration anesthesia. No difficulties have been encountered during the operation or subsequently. From this limited experience, we feel that we can say that in the patient with bilateral pneumothorax, necessary surgical intervention may be undertaken without undue risk, remembering, however, that fatalities may occur in these patients with

markedly reduced respiratory reserve from complications which would be well tolerated by an individual not so collapsed.

RESULTS

Extensive bilateral pulmonary tuberculosis is a very serious disease and one potentially very dangerous to life. The results obtained from its conservative treatment certainly fall far short of complete satisfaction, and any method which will improve the treatment of even some of these unfortunate individuals should be welcome, even though not perfect. Bilateral pneumothorax falls into this category, offering help to a limited group but certainly not a cure for all. The results presented should be considered in the light of the tuberculosis present rather than from the ideal of 100 per cent good results, which are not obtained by any method of treatment of this disease.

TABLE I

BILATERAL PNEUMOTHORAX SERIES

		ALIVE	DEAD
DISCHARGED. BILATERAL PNEUMOTHORAX		26	
Clinical success	20		
Partial clinical success	5		
Failure	1		
SANATORIUM PATIENTS		28	
Clinical success	12		
Partial clinical success	10		
Questionable (too soon to classify)	3		
Failure	3		
ATTEMPTED BILATERAL PNEUMOTHORAX		19	
Unil. pneumo. with contralat. phreniphraxis	7		
Unil. pneumo. with contralat. thoracoplasty	2		
Extrapleural paraffin pack with contralat. phreniphraxis	1		
Thoracoplasty	1		
Unilateral pneumothorax	1		
Questionable prognosis. No further collapse.	2		
Unfavorable prognosis. No further collapse.	5		
Dead			11
DEAD. BILATERAL PNEUMOTHORAX			36
Clinical success	3		
Partial clinical success	8		
Failure	25		
Total		73	47

From this series of 120 patients, 90 have actually received bilateral artificial pneumothorax to a greater or less degree. From this group, the treatment in 35 may be considered to have been clinically successful in that it controlled the tuberculosis, closed cavities, and rendered the sputum negative; 23 may be listed as partially successful, benefiting the patient to a considerable degree, reducing but not completely closing all cavities, while leaving the patient with some sputum usually negative but occasionally containing tubercle bacilli. Three of more recent

date must be listed as questionable, the time being too short to determine the results definitely. Twenty-nine must be classed as failures because of inability to collapse cavity, control tuberculosis, or render the sputum negative.

Table I clearly portrays the results obtained by this method at Glen Lake Sanatorium over the twelve-year period 1922 to 1934. Some of the apparent contradictions in this may be found explained in the subsequent discussion.

From the clinically successful group, 20 have been discharged from the sanatorium, 12 are still in residence, and 3 have since died. Fifteen of these patients are now working. Bilateral pneumothorax may give good results and save some patients from an early tuberculous death but cannot do so unless it be continued for sufficient time to permit healing of the disease, nor can it ever replace cooperation on the part of the patient or save him from paying the penalty for his own folly. True, its continuation may prove somewhat of a burden, particularly after discharge, but the same applies to paying insurance premiums. The two are continued for the same purpose; namely, protection. Exchanging the known for the unknown is frequently hazardous. The early discontinuation of bilateral pneumothorax may well prove disastrous if it was really needed originally. Later discontinuation of one or both sides may be considered, applying the same principles which should hold for the discontinuation of unilateral pneumothorax, namely, careful consideration of the original disease, the patient's ability to control it, the complications and the time elapsed since the pneumothorax was established. If then it is decided to attempt to discontinue the treatment, it should be done slowly and the patient carefully watched for any exacerbation of disease. The longest period of time that any patient has continued bilateral pneumothorax in this series has been five years and ten months. A number of patients have had one or the other side discontinued or lost for long periods of time, one for over nine years without further trouble. Others have been less fortunate and eventually succumbed to their tuberculosis.

The group in which partial clinical success has been reported includes 5 patients who have been discharged, 10 who are still in the sanatorium, and 8 who have subsequently died. Partial control of tuberculous lesions may occasionally be followed by good clinical results, but the opposite is more frequently true. The number in this group who subsequently died only too clearly emphasizes this point. Every effort should be made to obtain complete control of the lesion if possible.

A comparison of the results in the above groups with the results obtained in the "failure" group, however, is quite encouraging and indicates that much has been accomplished by the treatment. From the 29 patients classified as failures from the standpoint of bilateral pneumo-

thorax, 25 are now dead, 3 are still in the sanatorium, and only one is still alive outside the institution. She was discharged in 1925 and is still working and apparently in good condition.

The group of 30 patients upon whom bilateral pneumothorax was attempted unsuccessfully presents a picture which is quite discouraging except for a few individuals upon whom some other type of collapse has been substituted for the attempted bilateral pneumothorax. With 11 dead and 7 others in whom no other collapse was possible presenting an unfavorable or very questionable prognosis, this control group only too strongly emphasizes the need for some outside help in the group of patients selected for bilateral pneumothorax. A contrast of the results in this group and the "failure" group with those obtained where adequate collapse could be secured, only serves to make more of the good results appear quite miraculous.

CONCLUSIONS

Simultaneous bilateral pneumothorax has a definite though limited field in the treatment of bilateral pulmonary tuberculosis. Continued experience with it not only has increased our confidence in the procedure but has taught us much about the physiology of the chest and the extent to which other types of bilateral collapse may be carried. The results obtained to date would seem to warrant a wider application in selected cases of bilateral disease or contralateral extension during unilateral collapse.

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THORACOPLASTY VERSUS PNEUMOTHORAX*

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IN THE present status of surgical collapse treatment of ulcerative forms of pulmonary tuberculosis, we deal with two outstanding procedures, pneumothorax and thoracoplasty. Other surgical methods complete but do not replace these two procedures. Jacobaeus' closed intrapleural pneumolysis, open pneumolysis, and phrenicectomy do occasionally complete pneumothorax or thoracoplasty. Extrapleural apicolysis, phrenic nerve interruption by crushing, section or avulsion, scaleniotomy or intercostal neuronectomy, when considered as independent operations, are of relatively little value. Notwithstanding the enthusiastic support of phrenicectomy by O'Brien,[1] Nehil and Alexander,[2] Welles,[3] and others, who have reported closure of cavities by phrenicectomy alone in as many as 50 to 80 per cent of cases, the consensus of opinion today approaches more and more that which I advanced in 1932 on the small therapeutic value of this operation.

Of far greater importance is the question of the respective indications for pneumothorax and thoracoplasty. Should thoracoplasty be considered as a method to be applied only when pneumothorax has been unsuccessful or has failed or should it be accepted as a method having its proper indications? So far it has been considered as the orthodox method to begin with pneumothorax and resort to thoracoplasty only when pneumothorax has not been successful. Should this be the general rule? In other words, should we accept that we must begin with pneumothorax always and in all cases, or are there cases in which thoracoplasty should be considered as a more suitable procedure and applied right from the start without any attempt at pneumothorax? The discussion of this question is the object of this paper which is based upon my personal experience; therefore any extensive mention of literature will be avoided as much as possible.

There is no doubt that pneumothorax has rendered momentous service in the treatment of pulmonary tuberculosis; it has shown the importance of collapse treatment in the cure of this disease and has opened the way to the actual surgical treatment.

These valuable services, however, should not make us underestimate or ignore the shortcomings of this procedure. I shall mention the most important of them.

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First, pneumothorax treatment is a long procedure; it must be continued for years, and no one can say with certainty when it should be terminated. Often, following reexpansion of the collapsed lung, cavities reopen and again collapse becomes necessary. Furthermore, during long years of pneumothorax treatment the patient is limited in his activities and movements.

Second, with the exception of a few rare cases in which a strict selective collapse is obtained and successfully maintained, in order to secure and maintain an efficient collapse of the diseased areas, it is necessary to collapse the whole lung even when the lesions are limited to the apex and the lower lobes are healthy. We are thus obliged to produce an unnecessary physiologic suppression of perfectly healthy portions of the lung in order to obtain a satisfactory collapse of the diseased parts of it.

Third, in 60 per cent of cases, adhesions do not allow a satisfactory collapse of the diseased areas. In these cases the cavities remain open, whereas the healthy lung is collapsed. In such cases when the Jacobaeus operation does not bring about their closure, it is obvious that continuation of refills is not only useless but exposes the patient to further spread of the disease; on the other hand, patients with persistently positive sputum receiving ambulatory pneumothorax treatment constitute a danger to the community. Yet, every day, we see cases in which pneumothorax has been continued for months despite persistent patency of cavities and positive sputum. In numerous cases pneumothorax has been kept up, although the cavities existing at its induction have persisted, or increased in size, and even when new cavities have appeared. It is really appalling to see the number of actually far advanced bilateral and hopeless cases in which pneumothorax was induced while the lesions were still unilateral and limited and was maintained although incomplete from the beginning.

Fourth, the management of pneumothorax requires skill and experience which can only be acquired by long handling of tuberculous patients. Unfortunately such skill is not always available. Notwithstanding the notoriously insufficient training of medical students in tuberculosis, the use of pneumothorax is becoming more generalized every day and applied by men without the necessary special training. This practice leads to disasters which are observed in increasing numbers in our large hospitals for tuberculosis.

Fifth, pneumothorax, even when complete, is not free of serious complications such as spontaneous pneumothorax, tuberculous empyema, and especially empyema with mixed infection. Certainly, spontaneous pneumothorax may occur and does occur even without previous artificial pneumothorax. However, it is much more frequent in the latter cases, especially when artificial pneumothorax is induced in the early stages

of tuberculous consolidation. Ornstein has pointed out that the relatively more frequent spontaneous pneumothorax in colored patients is due to the greater frequency of massive caseous pneumonic forms and to the induction of artificial pneumothorax in the acute phase of the disease. Pure tuberculous empyemas have thus far been considered of no special danger to the patient. This may be true, but it cannot be denied that repeated and long continued punctures of the pleura, either for evacuation of the pus or for insufflation of air, expose to secondary infection and to production of empyemas with superimposed infections. These empyemas represent one of the more serious complications in the course of pulmonary tuberculosis, and its treatment is one of our most difficult and still unsolved problems.

Personally, as I know of no really efficient treatment of tuberculous empyemas secondarily infected, I believe that the best technic is to prevent pure tuberculous empyema from becoming secondarily infected; this can be done safely only by early thoracoplastic treatment of the pure tuberculous empyemas, especially when bronchial fistula is present. On the other hand, thickened pleura and presence of fluid and air in the pleural cavity often oppose a serious obstacle to successful thoracoplastic collapse. At any rate presence of empyema represents a not negligible source of postoperative complications following thoracoplasties.

Sixth, in cases with marked destruction of pulmonary tissue, even successful and complete pneumothorax, with closure of cavities and negative sputum does not definitely solve the problem of treatment of the disease. Often, in such cases, the lung cannot reexpand after refills have been discontinued, and, as the air is absorbed, the mediastinum and the heart shift toward the diseased side, causing marked vicarious emphysema of the healthy lung and dyspnea which are relieved only by again replacing the absorbed air. In such cases refills have to be continued for life, unless a secondary thoracoplasty is performed.

Seventh, a pleural cavity maintained for a length of time represents, surgically speaking, a potential danger of infection, especially when needling is kept on for long periods. Although the pleural serosa offers a marked defense to infection and a remarkable power of absorption of serous exudates even slightly infected, it is, as a rule, unable to resist such massive infections as are produced by bronchial or thoracic fistulas which are liable to develop at any time. It is precisely in order to avoid these dangers that surgeons always strive in intrathoracic operations to produce early and definite closure of the pleural cavity by the creation of adhesions between its two layers.

Last but not least, we should not overestimate the final results of pneumothorax. In 5,000 cases compiled from the literature which had been followed from five to ten years, it was shown, in round figures, that only in 40 per cent could total pneumothorax be induced, and of these

40 per cent, only from 40 to 50 per cent were followed by clinical cure; that is, in only from 16 to 20 per cent of all cases in which pneumothorax was attempted was clinical cure obtained.

These well-known shortcomings of pneumothorax described above have been detailed in order to show that this method, however efficient in a number of cases, is far from being a panacea in pulmonary tuberculosis. We should not lose sight of the fact that from 16 to 20 per cent, even 30 per cent, of cures mean from 70 to 80 per cent of deaths, which are appalling figures. These figures could be perfectly acceptable so long as there was no other method of treatment besides rest, which gave a maximum of from 10 to 15 per cent clinical cures. But today when thoracoplastic collapse yields from 40 to 60 per cent clinical cures, it does not sound reasonable that the phthisiologists should consider that they are bound to start the treatment with pneumothorax only because thoracoplasty has had a more elevated immediate postoperative mortality than pneumothorax. This reasoning is even less justified when we consider that the cures so far obtained by thoracoplasty were upon cases in which pneumothorax had been tried and failed. After all, what really counts in the treatment of pulmonary tuberculosis is how many of all treated cases are found alive and well five years after treatment and not only how many have died following thoracoplastic operations. I have the impression that phthisiologists who do not cooperate closely with the thoracic surgeon have a tendency to overestimate their successes with pneumothorax and underestimate the results of thoracoplasty. As for the bold statements formulated lately that thoracoplasty has never produced closure of cavities (Wiener and Fishberg[4]), the least one can say is that they represent hasty and immature reasoning based upon a small number of cases which were operated upon with a faulty surgical technic. Irrefutable proof of this was presented in a previous publication.[5]

But even the objections based on the high postoperative mortality of thoracoplasty are no longer valid.

With increasing experience and progressive perfection of our operative technic and postoperative care, morbidity and mortality of thoracoplasties and their final results have undergone radical changes. Actual mortality of thoracoplasties especially of partial ones is not over from 8 to 15 per cent, and clinical cures vary between 50 and 80 per cent. These figures warrant, I believe, a reconsideration of the accepted ideas on the collapse treatment of pulmonary tuberculosis.

The considerations presented above do not, by any means, lead to the conclusion that pneumothorax should be discarded and replaced by thoracoplasty. They only tend to prove that of the two methods thoracoplasty is more efficient and that they should be placed at least on an

equal footing; what I believe should be discarded is the actually prevailing conception that pneumothorax should be routinely tried first in all cases.

My contention is further strengthened by the study of the advantages of thoracoplasty over pneumothorax, and by our more recent knowledge of their respective physiologic action.

A first advantage of thoracoplasty to be considered is the marked shortening of the period of the treatment, which is of social, economic, and humane importance. Of no minor importance is the definiteness of the results obtained with thoracoplasty. In fact, with pneumothorax the results are doubtful until complete reexpansion of the lung has occurred; while with thoracoplasty, when closure of cavities has been obtained, the results are incomparably more definite. Epigrammatically one can say that our worries begin with pneumothorax where they end with thoracoplasty. They begin with the collapse of the lung in the first; they end when this collapse has been obtained with thoracoplasty. Of course, there are patients with thoracoplastic collapse in whom collapse of cavities cannot be obtained or patients who after good health and negative sputum for one, two or more years do again relapse. However, our postmortem studies on patients with thoracoplasty who died from other causes have shown that the cavities were perfectly closed, and that even in all cases with extension of the disease after successful thoracoplasties, most often the original cavities had remained closed. At any rate these relapses are by far rarer following thoracoplasty than pneumothorax.

Of all the evidence in favor of thoracoplasty, the most important to my mind is that derived from the mode of physiologic action of pneumothorax and thoracoplasty already studied and described elsewhere.[6] In fact, as long as it was believed that closure of cavities by pneumothorax as well as by thoracoplasty was due to the mechanical compression and collapse of their walls, there certainly was no reason to give the preference to thoracoplasty, since it is well proved that the first, when successful, can insure a more complete collapse of the lung than any successful thoracoplasty. But, if I am right in believing that mechanical compression of the walls of the cavities is only of secondary, if of any, importance in their closure, then the conception of "compression" is of no value, and the conclusions based upon it should be reconsidered.

There is strong evidence against the conception of closure of cavities being due to their mechanical compression and collapse. In fact closure of cavities by successful pneumothorax cannot be attributed to effective compression since in these cases, as a rule, the intrapleural pressure is maintained constantly negative; since intrapleural pressure measures the elastic recoil of the lung, it is obvious that it cannot be a question of compression of this organ by pneumothorax so long as this pressure

remains negative—which means that the lung is still partially distended. The same reasoning applies to cases in which only a few slender adhesions at the apex prevent closure of apical cavities, although air is present all around the lung; even positive pressure maintained for a long time does not succeed in closing these cavities. These facts show that the factor of compression and mechanical collapse is not sufficient to produce closure of cavities. Furthermore, it is not rare to see cavities increase in size under pneumothorax and even new cavities develop. How can these facts be accounted for by compression and the mechanical collapse theory? On the other hand, what explanation has this theory to offer for the spontaneous closure of cavities with or without bed rest, or for the sudden and spontaneous closure of cavities which have long resisted pneumothorax and do close occasionally notwithstanding re-expansion of the lung?

PHYSIOLOGICAL ACTION OF PNEUMOTHORAX AND THORACOPLASTY

The clinical evidence mentioned above and the more recent experimental data to be published in detail later, led me to believe that the really important factor in the closure of cavities is the closure of the bronchi through which cavities communicate with the bronchial tree and the outside world. I have endeavored to show[6] that the condition of patency or obstruction of these bronchi is the only factor which determines the persistence or closure of cavities. It thus becomes easy to understand how spontaneous closure of cavities can occur following spontaneous closure of the diseased and narrowed bronchial outlets. Allergic edema, inflammatory swelling of the mucosa or productive retraction of these outlets can cause temporary or definite closure of cavities. On the other hand, even a moderate collapse of the lung, which cannot produce closure of healthy bronchi, can bring about obstruction of the diseased and narrowed ones. For the same reason even slender pleuropulmonary adhesions may prevent closure of these bronchi and consequently closure of the corresponding cavities, although pneumothorax is present all around them. In fact, it is known that adhesions the section of which causes closure of apical cavities are, as a rule, the ones which are directed obliquely upward and backward, that is in the direction of the apical bronchus.

Development of the check-valve mechanism described by Jackson is easy in these "connecting bronchi" because of the condition of their diseased mucosa. In these cases development of obstructive emphysema and "ballooning" of the cavity may occur by the same mechanism as in a portion of the lung incompletely obstructed by a foreign body or tumor of the bronchus. This conception explains these peculiar variations in the size of cavities occurring within a short time and which so far could not be understood.

Conversely complete closure of these bronchi will, naturally cause gradual absorption of the air contained in the cavities, their gradual atelectatic shrinkage, and finally their disappearance, by exactly the same mechanism as in any other portion of the lung when atelectatic shrinkage and disappearance of the alveoli follow obstruction of the corresponding bronchi. Only the speed of closure of the cavities will depend upon and be regulated by the thickness of their walls, their permeability to gases and their mechanical resistance. Therefore thin-walled cavities will close much more rapidly than thick-walled cavities. When cavities are very large, when there is little or no lung tissue left around them and their connecting bronchi are relatively large, closure can seldom occur because of the difficulty of complete closure of their bronchial outlets and of absorption of gases contained in them. Exceptionally, however, these bronchi may close; in these cases the cavities may remain visible in the x-ray picture although the sputum has become negative, and at postmortem smooth-walled cavities without caseous content and often without tubercle bacilli are found.

It is obvious that the first effect of closure of the connecting bronchi is the disappearance of tubercle bacilli from the sputum, because of the severance of communication between the cavities and the bronchial tree. This fact clearly explains the so far puzzling disappearance of tubercle bacilli from the sputum sometimes occurring within a few days after successful pneumothorax or thoracoplasty. The second effect is the absorption of the gases and especially of oxygen contained in the cavities; the latter is due to the remarkable affinity of all tissues for oxygen (Warburg[7]), and to the fact that the avascular character of tuberculous tissues enhances this rapid absorption of oxygen. A condition of anoxemia and anaerobiasis is thus created in the cavity which causes the arrest of growth of tubercle bacilli (Novy and Soule;[8] Richardson, Loebel and Shorr,[9] Coryllos[6]). On the other hand, it is known that anoxemia in the tissues causes the development of fibrous tissue (Leriche and Policard[10]), so that the same causes will promote the production of fibrosis in the collapsed area. I have thus come to formulate a new theory based on clinical, experimental and postmortem evidence which explains the four stages in the collapse treatment of tuberculous cavities, namely, obstruction of their bronchial outlets, their gradual shrinkage and disappearance, the negative sputum, the disappearance of toxic symptoms, and the development of fibrosis.

With this conception the comparative study of the physiologic action of pneumothorax and thoracoplasty can be placed on a more solid foundation. An example will allow us to understand better the differences between these two procedures. It is known that when an unduly tight plaster splint is applied to the arm, as for example for a fracture of the humerus, which is tight enough to cut off circulation in the fore-

arm almost completely but not to a degree sufficient to produce gangrene, there very rapidly occurs, often within one or two weeks, complete fibrotic degeneration of the muscles of the forearm. Many such cases were reported during the World War. Muscular fibers disappear and the muscles of the forearm are transformed into rigid bands of fibrous tissue. This condition is known as the ischemic paralysis of Volkmann. On the other hand, it is well known that these fibrotic changes cannot occur when the application of the constricting bandage is only intermittent, even though it is equally as tight and the total time of its application is equal or even greater than in the above mentioned cases; this is because intermittent removal allows reoxygenation of the muscles and prevents prolonged anoxemia which is a necessary factor for the production of fibrotic degeneration.

The differences in physiologic action of pneumothorax and of thoracoplasty upon the lung are of the same order. In fact, collapse of the lung is always accompanied by ischemia of the lung proportionate to the degree of collapse.[11] In pneumothorax, collapse of the lung and consequently its ischemia are not steady. They are at maximum after refills and gradually decrease as the gases of pneumothorax are absorbed. On the contrary, in thoracoplasty, not only is collapse of the lung steady from the moment of its production and definite in character but it gradually increases as scar tissue develops in the operative wound. These differences of action explain the more efficient closure of cavities under the action of thoracoplasty and the greater development of fibrous tissue following this mode of collapse; this explains also that pneumothorax generally becomes more efficient a few months after its induction, when thickening of the parietal, visceral and mediastinal pleurae decreases their ability to absorb gas, stiffens the mediastinum, and renders more steady the collapse of the lung. The development of fluid often acts by the same mechanism.

COMPARATIVE STUDY AND INDICATIONS FOR PNEUMOTHORAX AND THORACOPLASTY

It is well known that in unilateral apical cavities, thoracoplasty performed in one or two stages of 3 ribs each, not only gives a higher percentage of clinical cures but also accomplishes this in an incomparably shorter time than pneumothorax. Furthermore, the nonaffected pulmonary parenchyma which represents in these cases one-half or even three-fourths of the affected lung is preserved, and thus clinical cure can be obtained with the minimum of sacrifice of lung parenchyma, of time and of expense.

Strictly apical unilateral cavities offer the most typical indication for immediate thoracoplastic collapse without previous attempt at pneumothorax and yield the most brilliant results. In my own statistics of 240

cases of thoracoplasty, with a total average mortality of 15 per cent, apical thoracoplasty in apical lesions gave 70 per cent clinical cures, and only 2.3 per cent mortality. In all of these cases thoracoplasty was performed because pneumothorax could not be induced and this only one to five years after the onset of the disease.

In cases with far advanced but unilateral lesions, when large cavities are present and most of the lung is destroyed, thoracoplasty is again more indicated than pneumothorax. In these cases complete pneumothorax can seldom be obtained; and even when it is, after its continuation for several years thoracoplasty is often necessary because of fibrotic retraction of the lung which renders its reexpansion impossible.

On the contrary, in cavities of the middle pulmonary field or of the bases and in the paramediastinal area, pneumothorax, with or without phrenic interruption, should be applied first; when successful it yields better results than thoracoplasty.

In a number of bilateral apical lesions, limited below on both sides by the second ribs anteriorly, bilateral apical thoracoplasty, in our experience, seems to be a better procedure than bilateral pneumothorax. In these cases the question of preserving the function of the lower lobes is of such major importance for the patient, that bilateral apical thoracoplasty offers greater possibilities for recovery than any other form of collapse treatment. In bilateral cases with apical lesion in one lung and extensive lesion in the other, thoracoplasty in the better lung can be efficiently combined with pneumothorax in the other.

In all other cases pneumothorax should be preferred to thoracoplasty as the initial method for collapse of the diseased lung, especially in patients with toxic phenomena, with extrapulmonary tuberculosis or too old for thoracoplasty.

Certainly additional experience in this field is necessary before definite statements upon the respective indications of pneumothorax and thoracoplasty can be definitely formulated. However, such experience cannot be gained unless we liberate ourselves from the routinely accepted ideas that pneumothorax should be applied from the start in all cases and under all circumstances.

I do not believe that we may any longer routinely apply to our tuberculous patients the "hit and miss" treatment of the sequence—rest—pneumothorax—phrenic interruption—thoracoplasty; the time has come when finer discrimination should be applied to the individual case. It is not reasonable that our more efficient method, which is thoracoplasty, be reserved for the cases in which the less efficient method, which is pneumothorax, has been applied and failed. Reason and experience point to the contrary.

My personal experience leads me to the conclusion that pneumothorax and thoracoplasty should no longer be considered as two stages

of the same procedure but as two different methods each of which has its proper indications. Furthermore, I believe that early thoracoplasties will increase the percentage of clinical cures, will shorten the time of treatment and will decrease the number of hopeless bilateral and far-advanced cases. In this way, until some more efficient treatment of pulmonary tuberculosis be devised, we shall come to a more satisfactory solution of the problem from social, financial, and humane standpoint.

SUMMARY AND CONCLUSIONS

A comparative study of the respective advantages and shortcomings and of the physiologic action of the two outstanding methods of collapse therapy of cavernous pulmonary tuberculosis, namely pneumothorax and thoracoplasty, led me to the following conclusions:

1. The routine application of bed rest, pneumothorax, and thoracoplasty with or without phrenic nerve interruption in the order named, and only if the preceding procedure was not successful, constitutes a "hit and miss" treatment which may lead to loss of precious time and irreparable disasters. Bed rest should not be prolonged beyond the time necessary to make certain the diagnosis of cavities. Once this diagnosis is made, no time should be lost with the hope of the remote possibility of their spontaneous closure, but collapse treatment should be applied without any unnecessary delays.

2. Pneumothorax should not necessarily be applied before thoracoplasty. Each of these procedures has its own indications. It should not be forgotten that thoracoplasty is a more efficient and expedient method of treatment than pneumothorax; therefore a greater discrimination in their respective indications should be attempted in each individual case.

3. In cavities of the extreme apex, in which pneumothorax seldom produces efficient collapse, apical thoracoplasty in one or two stages with resection of no more than 3 ribs in each stage should be considered as the method of choice, and no time should be lost with attempt at pneumothorax. Good results are obtained in from 60 to 80 per cent of these cases, with a mortality no higher than 5 per cent.

4. Thoracoplasty is a better procedure than pneumothorax in unilateral lesions with marked destruction of pulmonary tissue when the condition of the patient allows it; very often in these cases after prolonged collapse with pneumothorax reexpansion of the lung cannot be obtained and continuation for life becomes necessary.

5. On the contrary in toxic or aged patients pneumothorax should be attempted first. If successful collapse is obtained, it should be continued; if it is unsuccessful, thoracoplasty should be performed without delay if and when the condition of the patient permits it.

6. In bilateral cases exclusively located in the apices above the second rib, bilateral thoracoplasty is the method of choice. From 3 to 5 ribs

can be resected in both sides without any greater danger than in unilateral cases; this procedure allows the preservation of the lower lobes, which can only exceptionally be obtained with bilateral selective pneumothorax.

7. When pneumothorax has not produced a satisfactory collapse and section of adhesions cannot complete it, thoracoplasty should be performed without any delay. Incomplete pneumothorax should be considered as dangerous as no pneumothorax at all.

8. When pneumothorax cannot be induced, thoracoplasty should be performed without losing valuable time in expectation of spontaneous cure.

9. In basal cavities or cavities located very close to the hilum, pneumothorax appears to be a better procedure.

10. My conception of the physiologic mechanism of collapse treatment was briefly explained, and the respective merits of pneumothorax and thoracoplasty based on this conception were discussed.

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SCALENIOTOMY WITH OR SUBSEQUENT TO PHRENICECTOMY IN THE TREATMENT OF PULMONARY TUBERCULOSIS*

Report of 135 Cases

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IT IS not my intention, in reporting these results from scaleniotomy, to give an impression of undue enthusiasm for a minor collapse procedure. In this series of 135 cases, if more rigid selection had been possible, it would certainly have increased the percentage of outstandingly good results. Inasmuch as 56 per cent of our adult patients are far advanced on admission, we were forced to accept for operation many hopelessly advanced cases, with extensive bilateral tuberculosis, in whom palliation of symptoms could be the only goal. In many, artificial pneumothorax had already been found unsuccessful, and in some, pneumothorax was subsequently given or attempted for the same or contralateral lung. Others were preliminary to inevitable thoracoplasty or extrapleural pneumolysis. It must be evident, therefore, that the majority of our patients required any added advantage to be gained from combined scaleniotomy and phrenicectomy, or from subsequent scaleniotomy in those where phrenicectomy had been done previously without obtaining adequate improvement. In 37 cases, there had been prior phrenic nerve interruption, along with unsuccessful attempts at artificial pneumothorax, or else a pneumothorax rendered inefficient by a widely adherent apex. It was in these patients, who had independent scaleniotomy as a late supplementary procedure, that we had opportunity to study the effects of scalene section alone. We have tried to make some comparison between these and the patients who had simultaneous phrenicectomy with scaleniotomy. Fortunately for the purpose of evaluation, it so happens that some of our most striking scaleniotomy results occurred in cases where prior phrenicectomy had proved ineffective. However, it seems evident that double pulmonary relaxation, from above downward as well as in the opposite direction, should prove more effective than diaphragmatic paralysis alone, especially in the treatment of apical pulmonary cavities. An added reason may be found in the work of Gale and Middleton, Hoover, and Head, all of whom showed that after diaphragmatic paralysis there is often a definite

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increase in the excursion of the costal margins, resulting from overactivity of the intercostal muscles. Needless to say, careful consideration is necessary in selecting patients most likely to be benefited by scaleniotomy. Suggested criteria will be mentioned presently.

It is admittedly true of minor collapse measures that they may fall short of producing the desired results. We are in accord with those phthisiotherapeutists who feel that, dogmatically speaking, the best substitute for unsuccessful artificial pneumothorax is thoracoplasty. Yet, there are few of us but would welcome, for ourselves or our families, any reasonable hope of avoiding radical surgery by fair trial of a minor procedure for a *limited* period of careful observation. It is clearly established that phrenicectomy or scaleniotomy only leads to futile temporizing if we are faced with disease extensive enough to demand the swifter, more complete collapse afforded by artificial pneumothorax or thoracoplasty. Suffice it to say, our results permit a measure of encouragement to all who welcome helpful adjuvants to the present armamentarium of collapse therapy.

The ideal lesion in which to expect response to scaleniotomy is one situated above the anterior level of the second rib; even in this location cavities should be preferably not more than 4 cm. in diameter and relatively thin walled. If cavity be present, there should be sufficient elastic lung tissue surrounding it on all sides to permit enough resilience for fibrotic contraction. Cavities which are subpleural offer less hope of closure by simple pulmonary relaxation. In those patients who show decided elevation of the upper ribs on normal inspiration, scalene section affords greatest relaxation to an adherent lung apex.

Section of the scaleni anticus and medius releases the first rib, and section of the scalenus posticus the second rib, from the normal bucket-handle lift on inspiration. The function of the intercostal muscles is consequently impaired by the loss of this counter-pull. In the majority of cases this decrease in chest expansion is noticeable objectively after scaleniotomy, on both inspection and fluoroscopic examination. Slight narrowing of the upper hemithorax has been noted. Subjectively, many patients voluntarily note quieter respiration on the side of operation, and experience a sense of weight or oppression in the upper hemithorax. Occasionally, dyspnea occurs for a few days postoperatively. In one patient who had had bilateral scaleniotomy without phrenicectomy, the vital capacity was permanently reduced 350 c.c., or 14.9 per cent. Cough is customarily decreased at once, but the daily amount of sputum may show transitory increase, indicative of pulmonary contraction. In a human subject, immediately after death, Aycock found experimentally that a 40 per cent decrease in apical volume was produced by section of the scalene muscles.

The operative technic is relatively simple, although, like that of phrenicectomy, fraught with some potential pitfalls. Injury to the internal jugular vein or subclavian artery, or to the inferior trunk of the brachial plexus, constitutes the chief source of danger. Scaleniotomy

Fig. 1. Fig. 2.

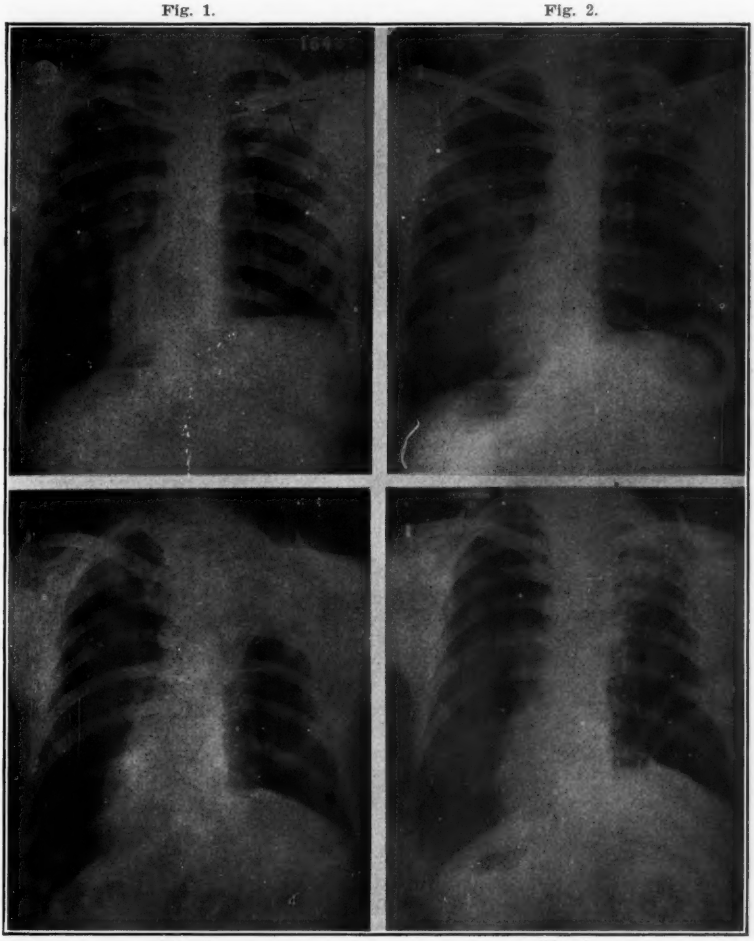

Fig. 3. Fig. 4.

Fig. 1.—Cavity 5 cm. in diameter in right apex unchanged for two years.

Fig. 2.—Cavity closed two weeks after scaleniotomy; phrenicectomy eighteen months prior.

Fig. 3.—Dense lesion with 6 cm. cavity present for three years.

Fig. 4.—Marked clearing and contraction in less than one month; phrenicectomy two years prior had resulted in no improvement.

is done through the customary phrenic incision, slightly above and parallel to the clavicle, under local anesthesia. When prior phrenic-

ectomy has not been done, the phrenic nerve is blocked, clamped, and severed close to its origin. Accessory phrenic roots are resected. Evulsion of the main stem is reserved until after scalene section, because exairesis elicits the chief discomfort of the combined operation. The

Fig. 5. Fig. 6.

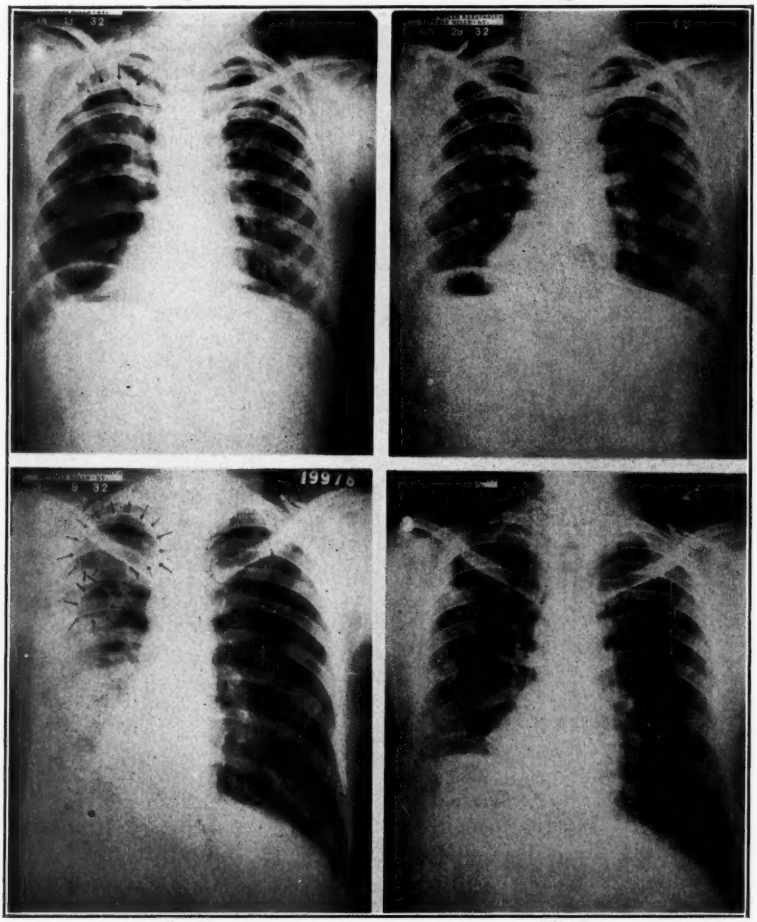

Fig. 7. Fig. 8.

Fig. 5.—Artificial pneumothorax unsuccessful in closing 5 cm. cavity in adherent apex. Phrenicectomy likewise unsuccessful after seven months' trial.

Fig. 6.—Cavity closed and sputum bacillus free only after scaleniotomy. Pneumothorax maintained but not distinguishable in illustration.

Fig. 7.—Extensive multilocular cavitation. Artificial pneumothorax unsuccessful due to complete pleural symphysis. No effusion present.

Fig. 8.—Marked clearing and closure of cavities within four months after scaleniotomy and phrenicectomy.

scalenus anticus is dissected free from the carotid sheath and brachial plexus, hooked up with a straight aneurysm needle as close as possible

to its insertion, and severed by low-heat galvanocautery which provides hemostasis. The side walls of the rather deep wound should be protected against heat radiation by wet saline packs. High-frequency cutting might be employed with facility for scalene section. The proximal and distal muscle stumps immediately separate from 2.0 to 2.5 cm. The plexus can then be retracted mesially, and the scalenus medius dissected out and divided. Caution must be taken to preserve the long thoracic nerve, which usually is found within the posterior sheath of the medius but occasionally traverses the belly of the muscle. The dorsal scapular nerve is usually encountered, also. The scalenus posticus is then similarly divided. The latter two muscles are often found to be fused. The muscles being insensitive, pain may be produced only by dissection or retraction of the brachial plexus and its branches. A slight transitory anesthesia or paresthesia in the arm or hand may be produced by incautious manipulation of the plexus, but any such effect rapidly disappears. No deformity or loss of function can be noted following scaleniotomy.

At operation, we have often observed marked activity of the scalene muscles, with strong contraction on inspiration. In patients who use their accessory muscles of respiration to such a degree, we may reasonably anticipate the maximum success in closing pulmonary cavities and rendering sputum bacillus free, in stopping hemoptysis, and in securing an afebrile course. We have, also, found preliminary scaleniotomy of great assistance during thoracoplasty, in rotating the first rib so as to facilitate resection anterior to the scalene tubercle. In a young patient with flexible costal cartilages, wide resection of the first rib might even be rendered unnecessary by preliminary scalene section.

SUMMARY

A total of 135 scaleniotomies is reported. Ninety patients were far advanced; 44 were moderately advanced; 96 had bilateral, and 39 unilateral, disease. One hundred and twenty-five patients had cavity, 72.6 per cent of these ranging in diameter from 2 cm. up to 8 cm. or extensive multilocular cavitation; 20 per cent showed honeycombing or a single cavity up to 2 cm. in diameter. One hundred and fifteen (85.2 per cent) had sputum positive for tubercle bacilli. Twenty-nine (21.5 per cent) had an established, inefficient pneumothorax before operation. The number of right- and left-sided operations is practically equal; 41 per cent were men and 59 per cent women; 13 (9.6 per cent) were colored patients.

Most of the combined operations were done in cases in which phrenic nerve interruption alone was judged insufficient to close the type of cavity present. The net results are no better than some of the statistics

reported by others for phrenicectomy alone, but the majority of the patients in this group had a worse type of disease than is customarily chosen for phrenic operation.

TABLE I

PREOPERATIVE STATUS

CLASSIFICATION	NUMBER OF PATIENTS		TERMINAL CASES	SIZE OF CAVITY				TUBERCLE BACILLI		ARTIF. PNEUMO. PRESENT
	UNILAT.	BILAT.		NONE	HONEYCOMB TO 2 CM.	2 TO 4 CM.	4 TO 8 CM. OR MULTILOC.	POS.	NEG.	
Minimal	1	0	0	1	0	0	0	1	0	0
Mod. adv.	21	23	0	8	14	22	0	30	14	4
Far adv.	17	73	30	1	13	26	50	84	6	25
Total	39	96	30	10	27	48	50	115	20	29
	28.9%	71.1%	22.2%	7.4%	20.0%	35.6%	37.0%	85.2%	14.8%	21.5%

Thirty patients (22.2 per cent) were terminal cases on admission; palliation of symptoms only could be expected, hence I have taken the liberty of excluding these from the table showing effects on cavity and positive sputum. They are, of course, included in the final classification. All in this group had extensive bilateral disease.

We have been doing scaleniotomy for only two and one-half years, hence sufficient time has not yet elapsed in many of our cases to permit judgment as to ultimate cure. The number of patients, likewise, is insufficient to warrant final conclusions. Therefore, we have made closure of cavities and negative sputum the chief criteria of success.

TABLE II

RESULTS EXCLUDING ADMITTEDLY UNSUITABLE CASES

SIZE OF CAVITY	CAVITY				SPUTUM POSITIVE				COMPLEMENTARY PROCEDURES SUBSEQUENTLY SUCCESSFUL
	PHREN. AND SCAL.		SUBSEQ. SCAL.		PHREN. AND SCAL.		SUBSEQ. SCAL.		
	CLOSED	UNCL.	CLOSED	UNCL.	NEG.	POS.	NEG.	POS.	
None (10)	–	–	–	–	8	2	0	0	0
Honeycomb to 2 cm.	4	16	2	5	6	10	3	4	4
2 to 4 cm.	17	17	4	7	13	8	6	5	5
4 to 8 cm. or multiloc.	4	8	3	8	4	6	3	7	2
Total	25	41	9	20	31	26	12	16	11
	37.9%	62.1%	31.0%	69.0%	54.4%	45.6%	42.9%	57.1%	10.5%

Thirty-four cavities (35.8 per cent) were closed by scaleniotomy, with or subsequent to phrenicectomy. The majority closed were cavities having a diameter of from 2 to 4 cm. "Honeycomb" cavities proved definitely refractory to closure. In addition, 11 cavities (10.5 per cent)

have been closed by complementary procedures; 5 by artificial pneumothorax, 3 each by thoracoplasty and paraffin plombage. Deducting the 20 cases with negative sputum before operation, 43 (50.6 per cent) were rendered bacillus free by scaleniotomy, with or subsequent to phrenicectomy. In addition, 11 (12.3 per cent) have been rendered negative by complementary procedures. These percentages are exclusive of the 30 unsuitable, terminal cases.

The percentage of improvement following independent, supplementary scaleniotomy is approximately as high as was obtained in the series of patients having simultaneous phrenicectomy. This apparently indicates that scaleniotomy alone may often produce the maximum benefit afforded by minor pulmonary relaxation. This was the procedure followed in 37 cases, 27.4 per cent of the series. Scaleniotomy was done anywhere from six months to three years subsequent to phrenicectomy. All of these patients had had more than six months of bed rest; in practically all, pneumothorax had been found impossible, or else unsatisfactory due to apical adhesions. Three had bilateral scaleniotomy. Excluding in this group the eight cases which were terminal at time of operation, 9 cavities (31 per cent) were closed, and in 12 (42.9 per cent) the sputum was rendered bacillus free by scaleniotomy alone. Four other cavities were closed subsequently by thoracoplasty or apicolysis.

TABLE III

PRESENT CLASSIFICATION—135 CONSECUTIVE CASES

CLASSIFICATION	NUMBER OF PATIENTS	ABLE TO WORK OR WORKING	ARREST-ED	APP. ARR.	QUIESC.	IM-PROVED	UNIMP. OR WORSE	DEAD
Minimal	1	0	0	0	1	0	0	0
Mod. adv.	44	17	16	6	12	7	2	1
Far. adv.	90	12	6	10	16	18	24	16
Total	135	29	22	16	29	25	26	17
	100%	21.5%	16.3%	11.8%	21.5%	18.5%	19.3%	12.6%

The present classification of 135 consecutive patients shows 21.5 per cent able to work or working, 28.1 per cent arrested or apparently arrested, 40 per cent quiescent or improved, and 31.9 per cent unimproved, worse or dead. Deducting the 11 cases (8.1 per cent) which are arrested or apparently arrested only after subsequent complementary procedures, there remains a total of 27 (20 per cent) in these two classifications as a result of scaleniotomy with or subsequent to phrenicectomy. We have included all patients operated on up to the first of this year; further changes may, of course, be expected in some cases. Two patients who were untraced are recorded as unimproved.

Scaleniotomy has been shown to be capable of standing on its own legs as an independent collapse measure, in selected cases. It is frequently a definite adjunct to phrenic nerve interruption. Obviously,

careful selection of cases is essential in order to obtain the most favorable results. To depend upon a minor collapse measure when thoracoplasty is indicated is to incur unjust criticism of a useful adjuvant procedure.

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RESULTS OF OPERATION WHICH INTERRUPTS NERVE IMPULSES ALONG THE PHRENIC NERVE PATHWAY

Indications and Contraindications for Its Use*

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IN VIEW of the thousands of cases of pulmonary tuberculosis treated by operation on the phrenic nerve, it is timely to consider on both practical and theoretical grounds not only the benefits that may be accomplished but also the ill-effects which may ensue following such a procedure.

There is no doubt in my mind that operations on the phrenic nerve have been of material aid in the treatment of pulmonary tuberculosis. Since Felix first suggested it, it has been employed more and more extensively, and today it is recognized as a helpful procedure. Because it is a simple operation requiring little more than ordinary surgical skill and only a moderate knowledge of anatomy, every well-trained surgeon can perform it. Herein lie certain dangers. This report will draw attention to some of these dangers. It is based on a long experience at Bellevue Hospital in New York, where a large tuberculosis service exists, with an annual turnover of more than 3,000 patients. At Bellevue there is a unique opportunity to observe the varied results of treatment as practiced elsewhere, because the hospital serves in a large measure as a clearing house for an enormous local population; because, being situated in the nation's metropolis and principal seaport, its patients come from all quarters of the globe; and because, being a free municipal hospital, many of its patients come from other institutions, having exhausted their financial means of meeting the expenses of treatment and care therein.

The very fact that these patients still require hospital care implies that their previous treatment has failed to accomplish a cure. As a basis for this review we have selected cases of failure from our own series in addition to those entering the hospital having had the operation performed elsewhere. We are aware that in the latter group the previous condition is not known, and conclusions can be drawn solely from the conditions as presented.

I shall not offer the customary elaborate tables of statistics showing the number of cases operated upon with relative percentages of cured, improved, unimproved, and died. Valuable as such tables may be to

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any individual operator, they fail to convey an inkling of the contraindications to the operation, nor do they as a rule analyze minutely the causes of the relatively few failures reported in any series.

An extensive perusal of the literature leaves the impression that many authors feel that the operation is still *sub judice,* and write more as advocates than in a spirit of critical analysis as to either its actual or relative value.

This may explain the widespread use of the operation in cases for which it was never intended, in which the chances of its success are nil, and in which it may do positive harm.

We, as thoracic surgeons, have of course a primary obligation to our patients, but in addition we should decry the indiscriminate performance of an eminently useful operation by those who fired by enthusiasm in reading statistics have neither a correct conception of the potentialities of the operation nor an expert knowledge of pulmonary tuberculosis. It is unfortunate for everyone that repeated dismal failures engender among internists an unwarranted prejudice against the entire subject of surgery in the care of pulmonary tuberculosis.

It is well in considering indications and contraindications for the operation to summarize what occurs following interruption of nerve impulses along the phrenic pathway. One-half of the diaphragm is paralyzed, and eventually its muscular fibers atrophy and are replaced by fibrous tissue. This is complete and confined to one-half of the diaphragm as shown by Stanbury reporting on autopsy material examined after periods varying from four months to eleven years. A paralyzed diaphragm is more or less flaccid depending on changes in its structure, and its movement is dependent on the intrapulmonary and intraabdominal forces which act upon it. The resultant of these forces will determine its eventual stationary position, which is usually more cephalad than before it was paralyzed and is spoken of as a high position of the diaphragm. Coincident to this change of position the size of the superimposed lung is diminished, and the tension of its tissues is in some measure relaxed. At the same time the intraabdominal organs, especially the liver on the right side, the stomach and intestines on the left, ascend and encroach on the space between the lower ribs and the median line. The dome of such a diaphragm may assume two types, one a broad flattened form whereby the lateral costophrenic sinus is obliterated, and second a rounded or peaked dome the curve of which has a shorter radius than the former, and in which the lateral costophrenic sinus may or may not be obliterated in some measure. It cannot be doubted that the degree of relaxation of the tension in the pulmonary tissue will vary with the extent and character of the rise of the diaphragm.

Parodi maintains that gravity plays an important rôle in determining the degree of intrapleural pressure and that the inherent retractile property of the pulmonary tissue is not the only factor. Reasoning from the laws of mechanics, he places the center of gravity of the lung at a point about 5 cm. external and anterior to the hilus on a horizontal plane passing through the hilus. He believes that the tension forces in the lung radiate about this center of gravity. The resultant of these tension forces are two vectors, one acting in a vertical direction and the other in a horizontal one. He concludes from this that a rise in the diaphragm in a high peaklike dome relaxes only the vertical forces, leaving the horizontal unaffected; while a rise of the diaphragm in a broad complete manner will relax both the vertical and the horizontal tension forces. We are not convinced that this is the correct explanation of the causes of failure in certain cases, but we are confident that a mere statement as to the extent of the rise of the diaphragm is not the sole criterion on which to judge the efficacy of the procedure in any given case.

The elimination of the phrenic nerve pathway abrogates an important link in the coordinating mechanism between the various factors entering into the function of breathing in that during the respiratory cycle the intercostal and abdominal muscles act less vigorously. This together with loss of contractile power in the diaphragm results in a diminution of expansion and contraction of the lung during respiration and effects a certain degree of rest in the pulmonary tissue.

Not only do important changes occur in the pulmonary circulation, viz., dilatation of capillaries and slowing of blood stream, but also in the general circulation there is less efficient emptying of the superior and inferior vena cava and a loss of a pumplike action as an aid in filling the auricles. That very few patients show any permanent demonstrable ill-effects from this circulatory interference means that they have developed a compensatory mechanism to offset it. This compensatory ability varies with individuals. That it is efficient under ordinary circumstances in most patients is shown by the fact that they experience little or no discomfort following the operation, but this compensation is relative and on exertion may fail, and dyspnea and shortness of breath may become a distressing symptom.

Graham and others have demonstrated that following diaphragm paralysis the effectiveness of cough in expelling lipiodol introduced into the lung is interfered with in that "the elimination of iodized oil from the lungs is retarded" and that "on some occasions coughing may actually drive material, such as lipiodol, more deeply into the lung." We realize that there is a wide divergence of opinion among equally conscientious observers in respect to the influence which diaphragm paralysis has on cough, but in view of our own experience and the testi-

mony of others the possibility of such interference should be reckoned with, and in the presence of profuse expectoration one should pause and consider the advisability of recommending a phrenic operation no matter what may be the nature of the pulmonary lesion.

We have had too small an experience with the operation in patients who were formerly benefited by bed rest alone to express an opinion, but we agree on theoretical grounds with Alexander, whose large experience carries conviction, that a broader basis for the use of the operation in such cases should prove of value.

A considerable number of patients have come under observation at Bellevue Hospital who have been subjected to a phrenic nerve operation, who present large cavities having their walls firmly adherent to the parietes and virtually occupying the entire apex of the thorax. Such cases are among the most difficult to close even with an adequate thoracoplasty; to expect a simple diaphragm paralysis to accomplish anything for them is unreasonable; and to condemn the operation as entirely useless on such grounds, as is done by some internists, is unwise. The dangers and evil consequences due to the loss of effectiveness of coughing are frequently seen in such cases, where the secretion is abundant and the dangers of a bronchogenic spread into the lower lobe are enhanced. A phrenic operation should not be performed on such patients even if it is the only procedure to which the patient will consent.

A second group of patients have been observed with an extensive chronic diffuse fibroid or fibrocaseous lesion. Here the chances of benefit following the operation are indeed small. It has been performed with the idea apparently that the patient having drawn the mediastinum over toward the lesion, and having narrowed the rib spaces will, with a little help, effect a cure. Here the disease process has largely replaced the elastic tissue in the lung by dense fibrosis; the diaphragm is often a firm immobile structure; and the operation accomplishes nothing.

The operation at present is probably performed most frequently as an aid to the closure of cavities. Here the greatest amount of judgment is required. Probably the most brilliant results and also the greatest disappointments or failures will be found among this group. Here the entire question revolves about the proper selection of cases. The widespread idea among the inexperienced, that every cavity will collapse if the pulmonary tissue is sufficiently relaxed, is not justified by experience. On the contrary, all of us have encountered cases in which cavities do not close even after the pulmonary tissue has been relaxed by a thoracoplasty to a greater degree than is ever possible by an operation on the phrenic nerve, and some form of actual compression is required to supplement relaxation in order to effect a closure. Cavities should be judged from two standpoints: their exact site, and the nature and extent of the surrounding lesion.

In considering the site of the lesion the relation of the cavity to the chest wall is more important than whether it is in the upper, middle or lower lobe. We classify cavities as central or peripheral. The centrally located cavities are those surrounded completely by more or less normal lung tissue; and the peripherally located cavities are those which have more or less of their walls adherent to the parietes of the chest. The latter relationship jeopardizes the chances of a successful result of the operation in proportion to the extent of this adherence.

The nature and extent of the lesion surrounding the cavity are, however, the most important factors in estimating the chances of success to be derived from the operation. Experience with pneumothorax has shown that at times in recent fresh lesions a partial collapse may favor rather than control the spread of a fresh soft pneumonic lesion; and where several caseating cavities are present, it may favor their coalescence. Therefore, we are opposed to phrenic operations in any case until there has been established a certain degree of stabilization as evidenced by frequent x-ray studies on the course and development of a given lesion. The most favorable cases are those presenting cavities centrally located surrounded by zones of young soft fibrous tissue, and which are comparatively well stabilized as evidenced by no fever or toxemia. Whether the lesion is situated in the upper, middle or lower portions of the thorax does not appear to influence the prognosis. As this zone surrounding the lesion becomes more dense and more organized, the efficacy of the operation diminishes; and in the cases in which firm fibrous strands exist which extend from the walls of the cavity outward to the parietal pleura, a condition develops in which the tension forces are completely altered. Whereas in the first group relaxation of the tension forces acts in a concentric manner favoring collapse, in the latter, eccentric tension forces arise from partial collapse whereby the fibrous strands acting from their fixed points on the parietes actually tend to pull apart the walls of the cavity and prevent its collapse. This action is seen most frequently in apical lesions where the confines of the thorax are limited in extent, unyielding and rigid.

As stated above, Parodi believes that this is more liable to occur in cases in which the diaphragm has ascended in a peaklike dome, maintaining that here the vertical tension forces have been relaxed while the normal horizontal tension forces remain uninfluenced.

The use of the phrenic operation as a preliminary step to thoracoplasty is still a subject of dispute. Although it has strong adherents, our experience has led us to abandon its use as a routine procedure, and today we employ it only in those cases in which it may serve as an aid to the patient in stabilizing the lesion. These cases have become surprisingly few in recent years. The possibilities of interfering with the effectiveness of the act of coughing and in consequence increasing

the dangers of a bronchogenic spread, outweigh the possible advantages in lesions which are in themselves not favorable for phrenic operation. Prolonged bed rest in these cases has proved a safer procedure.

We have always favored and still believe that the first stage of a thoracoplasty should begin with removal of the upper ribs, and the cases which have undergone a preliminary phrenic operation have, in our experience, had a stormier postoperative course. The lower portions of the lung become suffused with secretion as shown by diffuse density on x-ray examination during the first few days following operation. These patients run a febrile course at times sufficiently elevated to be alarming, and they have greater difficulty in raising the secretion by coughing.

In addition, we have found that the rise of the diaphragm with the consequent rise of the intraabdominal organs has been a real obstacle in effecting a satisfactory collapse of the lower and middle regions of the lung in the subsequent and later stages of thoracoplasty because the abdominal pressure tends to hold outward the chest wall from which the lower ribs have been removed. We also believe that an active diaphragm by its inherent muscular tonus and contraction will pull inward the anterior ends of the resected lower ribs and will also aid the action of gravity in drawing inward the upper chest wall after removal of its support of the upper ribs by maintaining a constant downward traction on the pulmonary tissue, and thus will aid collapse.

At Bellevue we may have seen a darker side of the picture than others, but despite these dismal examples we still believe that the phrenic nerve operation is an aid, but only an aid, in the treatment of properly selected cases of pulmonary tuberculosis. We are, however, unable at the present time to predict with certainty what will be the result of the operation in any given case, but believe the answer to that question can only be found by a thoughtful analysis of the factors which are presented by each individual patient.

THE RESULTS OF EXTRAPLEURAL THORACOPLASTY IN THE TREATMENT OF PULMONARY TUBERCULOSIS*

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EXTRAPLEURAL thoracoplasty has been generally understood to imply the posterior resection of all the ribs except the twelfth after the method of Sauerbruch or of Brauer, but in recent years a thoracoplasty involving the resection of a limited number of them is being increasingly favored for certain indications. It has been termed partial in contradistinction to the widely used total thoracoplasty. The partial thoracoplasty involves the resection of the upper ribs and usually much longer segments of them than does the total operation. Often the whole lengths of the first and second ribs are excised, the object being to limit the collapse as far as possible to the diseased portion of the lung but to make that very complete.

Extrapleural thoracoplasty also includes the resection of the anterolateral segments remaining after a total or partial posterior resection, but this operation is practically always auxiliary to the posterior.

Both the total and the partial thoracoplasty may be, and often is, preceded by a phrenicoexeresis or nerve crushing. Some surgeons employ it routinely, others only exceptionally. Sometimes the phrenicoexeresis is done secondarily. Inasmuch as there is no uniform procedure, and as a rule, no distinction made between cases that have or have not had a phrenic nerve operation in reporting results, no effort has been made in this presentation to study any differences produced by this procedure auxiliary to thoracoplasty.

The individual results of the more standardized posterior thoracoplasty have been reported in large numbers. In 1926, Alexander reviewed the combined results in 1,159 cases, but since that time no comprehensive study has been published.

In this presentation the authors report their own results in 200 and those of others in a total of 3,762 cases, all reported since 1926.

The results from different clinics are not strictly comparable because the conditions affecting them differ. Among such variable conditions may be mentioned differences in indication for the operation and in economic status of the patients, variations in operative procedure, differences in classification of results and length of time the patients are under observation after their discharge. If indications are strict, the re-

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sults will be relatively superior, but some patients whose only chance of recovery lies in the operation will be denied that chance; in proportion as indications are extended to relatively unfavorable cases, the mortality percentage will increase and that of clinical cures will decrease, but within certain limits a larger number of patients will be benefited. An extensive collapse of the diseased portion of the lung in a given number of stages is likely to involve a higher postoperative mortality than a more limited collapse, but there will be also a larger proportion of satisfactory results among patients who survive. Doing the thoracoplasty in stages extends the indication for operation to patients otherwise in too poor condition; this in turn increases the number of patients benefited but lessens the percentage of favorable results. An adequately managed convalescence for a sufficient length of time for the completion of the healing process is an important condition for permanent arrest of the disease. Economic stress may induce the patient to go to work too soon. There is no generally accepted standard of classification. Disappearance of bacilli from the sputum, ability to work, and freedom from symptoms, all for a period of one or two years or more, are among the requisites given for a clinical cure. However, a complete and permanent arrest of the tuberculous process constitutes a cure of the disease, even though the patient may not be able to work, in the same sense that a leg amputation may cure a patient of a sarcoma even though he can never again walk normally. An operation can scarcely be expected to make a robust individual out of one constitutionally frail; ability and willingness to work are not necessarily synonymous; some patients with bacilli in their sputum can and do work. A cough with a little bacilli free sputum from a chronic bronchitis may persist after an enduring arrest of the tuberculous process. Differences in opinion based on such considerations nevertheless may lead some to classify a patient as improved that another will put down as clinically cured.

A patient considered clinically cured two years or more after operation may eventually die of tuberculosis of either lung or elsewhere; many die from visceral damage acquired during the progress of the disease or from other causes entirely independent of it. The longer a given series is followed the larger will be the percentage of total deaths.

Such variable factors in considerable measure vitiate the significance of comparative statistics and yet, compiled and studied with discrimination they furnish, as in any other field of clinical medicine, a means of obtaining a perspective of results under existing limitations and of how they may be improved.

This study is based on a review of the authors' experience with 200 thoracoplasty cases and on 3,762 from the literature. A brief survey follows of the results of partial thoracoplasty.

The age and sex of the authors' patients are given in Table I .

The results are presented as to operative complications, early and late mortality, with causes of death, and as to degree of improvement and duration of favorable outcome. Since there is no standard classification of results, an arbitrary one must be chosen.

TABLE I

AGES OF PATIENTS	MALE	FEMALE	TOTAL
15-19 years	1	3	4
20-29 years	36	44	80
30-39 years	50	36	86
40-49 years	16	11	27
50-59 years	3	0	3
Totals	106	94	200

At the seventh international congress on tuberculosis, Bull reported 401 personal and collected cases from Norway classified as follows: dead, at stated time intervals since operations in numbers and per cent; living: Group I, able to work, no tubercle bacilli in sputum, practically symptom free; Group II, able to do some work, not bacilli nor symptom free; Group III, not able to work, bacilli in sputum; Group IV, results not evident; Group V, not traced.

At the same congress and later others have reported relatively large series similarly classified. Because of its simplicity and practicability and because of the relative large number of reported series of cases so reported or sufficiently detailed for such rearrangement, it has been adopted for this study.

In this classification it will be noted that the cases group themselves into those living and those dead at the time of the report with a few additional untraced. Grouping deaths by time intervals since operation avoids the difficulty of trying to reconcile conflicting opinions as to what constitutes death due to operation. Those occurring within a few weeks are probably almost exclusively due to it, as are also a large number of those during the second month. Those during the first eight weeks not due to operation as such may be due to an accident predisposed to by it or to progress of the disease stimulated by the operation or persisting in spite of it. The distinction between operative and nonoperative deaths in any case seems of secondary importance.

The time of death and relation to operative stages in the authors' series are shown in Tables II and III.

The combined mortality during the first eight weeks in a total of 3,811 cases in 24 series (by authors indicated by an asterisk in the bibliography) was 410 deaths, or 10.5 per cent. The individual variations were between 3 per cent and 21 per cent.

Ten authors (indicated by dagger in the bibliography) reported their early mortalities from two to twelve weeks after operation. Among

792 patients it was 115 deaths, or 14.5 per cent. The variations in the different series were from 7.1 per cent to 25.8 per cent. In some series the two-week mortality was greater than in others after twelve weeks.

TABLE II

TIME OF DEATH—AUTHORS' SERIES	UNCOMPLICATED	EMPYEMA CASES	TOTAL
First week	4	4	8
Eighth to fourteenth day	4	1	5
Fifteenth day to second month	9	3	12
2 mo. to 3 mo.			
3 mo. to 6 mo.	2	1	3
6 mo. to 12 mo.	5	3	8
1 yr. to 2 yr.	2		2
2 yr. to 3 yr.	1	2	3
3 yr. to 4 yr.	2	1	3
4 yr. to 5 yr.	9		9
5 yr. to 6 yr.	1		1
Totals	39	15	54

TABLE III

MORTALITY IN RELATION TO STAGE OF THORACOPLASTY—AUTHORS' SERIES

STAGE THORACOPLASTY	UNCOMPLICATED	EMPYEMA CASES	TOTAL
First	4	5	9
Second	5	0	5
Third completed	2	2	4
Third incompleted	1	0	1
Fourth completed	1	0	1
Secondary anterolat. first stage	3	0	3
Secondary anterolat. second stage	0	1	1
Secondary anterolat. third stage	1	0	1
Totals	17	8	25

Many surgeons report a lower postoperative mortality for their more recent series. Gravesen's was 10 per cent for his first 100 cases and 5.4 for the next 111 cases. Others report a still more considerable reduction, but such later series include a large proportion of partial thoracoplasties.

Bull has called attention to the very much greater mortality in his own experience and in that shown in his collected series for right-sided thoracoplasties, especially in the male. Among 32 males who had thoracoplasties on the right side the mortality was 21.7 per cent; among 45 on the left side it was 2.2 per cent. Our own experience, on the contrary, shows that among 38 males operated on the right side the mortality was 2.6 per cent, on the left side it was 18 per cent. Sauerbruch, Jessen, and Denk report results similar to those of Bull; Key and Corylles' results similar to our own; Nyström's mortality for the two sides was about the same.

In a combined total of 1,139 cases reported by the authors mentioned, with 152 deaths the distribution of them according to sex and side was as follows: male, both sides, 14.8 per cent; female, both sides, 12.1 per

cent; right side, both sexes 16.6 per cent, left side, both sexes 11 per cent; male right side 18.4 per cent, left side 11.9 per cent; female right side 14.3 per cent, left side 10.2 per cent. This number, however, includes a large proportion of patients who had extensive operations in one or two stages. Our own series shows a higher mortality for males than for females but a higher combined rate for the left side than for the right.

Bull and others believe that their higher mortality rates for males with right-sided lesions is due to an embarrassment of the venous return

TABLE IV

DEATH RATE OF PATIENTS IN RELATION TO TIME INTERVAL BETWEEN OPERATION AND DEATH

AUTHORS	HEDBLOM	SAUERBRUCH	BULL ET AL.	SCHEDTLER	KEY, DENK AND DOMANIG		NYSTRÖM	JESSEN	CARTER
Patients	161	701	401	200	190	109	95	61	52
Deaths within 7 days	2.4	3.2	5.5		1.1	14.67		4.9	3.8
Within 14 days	4.8		8.5		4.2	23.85		8.2	11.5
Within 21 days						26.6	14.7		
Within 28 days		13.2	9.5		7.4		14.7	9.8	
Within 42 days									
Within 2 months	10.5		11.0	8.5	9.5			11.5	
Within 3 months	10.5		13.5		10.5		22.1		
Within 6 months	11.8		15.75		11.1	37.6	23.1		
Within 12 months	14.9	22.2	18.0	20.0	17.4	46.8	26.3	11.5	17.0
Within 2 years	16.1		22.1	25.5	20.0	55.9	30.5	14.8	
Within 3 years	16.7		26.4	28.0	26.3	60.5	30.5		19.2
Within 4 years	18.0		30.9	31.0	26.8			16.4	21.1
Within 5 years	23.6		34.5	32.5			32.6		
Within 6 years	24.2		36.2	33.0					
Within 7 years									
Within 8 years							34.7		
Within 9 years				33.5	27.9	61.4			
Within 10 years									
Within 11 years		29.5			28.9				

due to compression and distortion of auricles and vena cava. In support of this view Bull cites his findings of 11.7 per cent mortality among 43 patients with right-sided lesions operated in two stages as against a 37.5 per cent mortality among 40 patients operated in one stage. This would also suggest that the authors' lower mortality for the right side following operation in 3 or more stages is due to the time it allows for readjustment of the intrathoracic pressure relationship.

Denk states that the seasons influence postoperative mortality and cites his own 4.5 per cent for 133 operations performed between April and September and of 13.8 per cent among 165 operations performed between October and May. Our own mortality, on the contrary, was

2.1 for 334 operations during the winter and 6.2 per cent for 273 operations during the summer. The experience of others in this matter would be of interest.

In the authors' series there were 25 deaths during the first eight weeks after operation. Eight of the 25 patients had a complicating empyema, and all of these were very poor operative risks. Seven of the total number died of cardiac failure, two of wound infection, ten of pulmonary complications including a respiratory failure the second day, two of embolism and one of rupture of an unrecognized empyema into a bronchus following a second-stage thoracoplasty.

In a combined series of 319 deaths reported by Bull, Schedtler, Denk and Domanig, Lambert and Berry, Alexander, Coryllos, Archibald, Piotet and Urech and by Wangensteen and the authors 8.3 per cent of

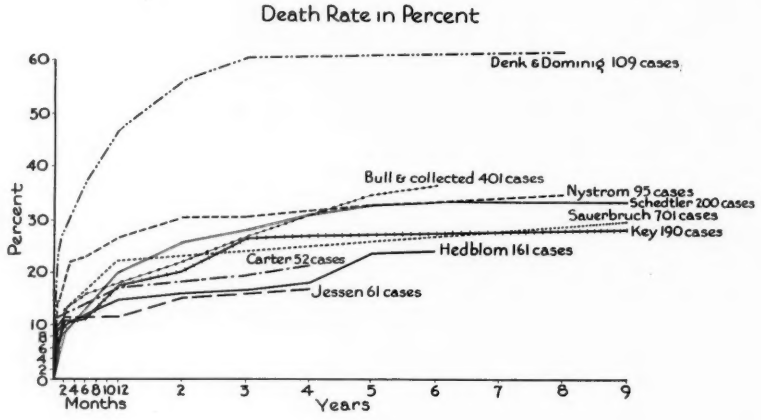

Fig. 1.

the deaths were reported due to shock, 21.3 per cent to heart failure, and 2.9 per cent due to mediastinal flutter. Wound infections accounted for 8.3 per cent. Pulmonary complications nonspecific and tuberculous included about 38 per cent.

The early and late deaths in percentage were reported in some detail in a few of the series as shown in Table IV and in a graph in Fig. 1.

The total mortality during the first four weeks was from 7.4 to 13.2 per cent of the patients operated; at the end of eight weeks, from 8.5 to 14.7 per cent; at the end of six months, from 11.5 to 23 per cent; at the end of a year, from 11.5 to 26.3 per cent; at the end of two years, from 14.8 to 25.5 per cent; and at the end of five years 23.6 per cent in our own series, and between 32 and 34.5 per cent in those of Bull, Schedtler and Nyström. Two striking facts brought out by these

figures and the graph is that the initial mortality during the first eight weeks was from one-third to more than one-half of that during the first five years after operation and that the death rate after this period decreases progressively but gradually.

The number of patients in Group I (living, symptom free and able to work), is shown in Table V: with the number of years of freedom from symptoms since operation.

TABLE V

GROUP I

LIVING AND ESSENTIALLY SYMPTOM FREE AND ABLE TO WORK. NO TB. IN SPUTUM

			YEARS AFTER OPERATION													
AUTHOR	YEAR	CASES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL
Hedblom	1934	200	9	10	18	17	16	12	3	6							91
Bull et al.	1930	401	13	14	24	17	16	16	11	7	9	4	3	0	0	2	136
Key	1930	132	13	9	7	5	5	5	6	2	2	1	2	3	0	0	60
Schedtler	1931	200	19	19	14	13	7	7	4	1	0	2	0	0	0	1	87
Nyström	1931	50	3	1	0	0	0	4	3	2	1	1	0	0	3	0	18
Denk and D.	1930	109	3	3	9	11	8	7	7	3	3	1	0	0	0	0	55
Berard and D.	1927	91	1	5	0	7	3	3	5	0	0	1	0	1	1	1	26
Carter	1931	52	0	0	3	5	4	2	8	2	0	0	0	0	0	0	24
Totals		1,235	61	61	75	75	59	56	45	23	15	10	5	4	4	4	497

87 per cent of the group 2 years or more after operation
45.1 per cent more than 5 years after operation

Our own series shows 45.5 per cent of all the patients operated in this group after one year and 41 per cent after two years. Of a total of 1,235 patients 496, or 40.1 per cent, were in this group after one year and 35.4 per cent more than two years.

The number in Group II (living and able to do some work but not entirely bacilli or symptom free) is given in Table VI.

TABLE VI

GROUP II

LIVING AND ABLE TO DO SOME WORK. NOT SYMPTOM FREE

			YEARS AFTER OPERATION													
AUTHOR	YEAR	CASES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL
Hedblom	1934	200	4	0	2	0	2	1	0	1	0	0	0	0	0	0	10
Bull et al.	1930	401	22	10	12	7	6	2	5	1	0	1	0	0	0	0	66
Key	1930	132	5	3	2	0	2	1	0	0	2	0	0	1	0	0	16
Schedtler	1931	200	7	12	2	6	8	0	2	0	0	0	0	0	0	0	37
Nyström	1931	50	0	2	1	1	0	1	1	1	1	0	0	0	0	0	8
Denk and D.	1930	109	4	4	5	2	2	1	1	0	2	0	0	0	0	0	21
Berard and D.	1927	91	7	4	3	1	1	0	0	0	0	0	0	0	0	0	16
Carter	1931	52	0	0	1	2	3	1	1	0	0	0	0	0	0	0	8
Totals		1,235	49	35	28	19	24	7	10	3	5	1	0	1	0	0	182

73 per cent of the group 2 years or more after operation
28 per cent of the group 5 years or more after operation

TABLE VII

SUMMARY OF RESULTS ONE OR MORE YEARS AFTER THORACOPLASTY

AUTHOR	CASES	LIVING				TOTAL	UNKNOWN	DEAD—TIME AFTER OPERATION											TOTAL DEAD
		I	II	III*	IV†		V	FIRST 8 WK.	9 WK.-6 MO.	6-12 MO.	YEARS 2	3	4	5	6	7	8	9	11	
Hedblom	168	91	10	10		111	3	25	3	5	5	4	2	9	1	0	0	0	0	54
Bull et al.	381	136	66	21		223	6	43	19	9	17	17	18	15	6	3	3	2	0	152
Schedtler	200	87	39	3		129	4	17	0	23	11	5	6	3	1	0	0	1	0	67
Denk and Domanig	176	55	21	8		84	25	29	12	10	10	5	0	0	0	0	1	0	0	67
Key	132	60	16	6		82	4	13	3	8	5	9	3	1	0	0	0	2	2	46
Ruber and Waitz	80	21	12	2		35	7	9	8	4	5	1	3	2	0	2	2	1	1	38
Carter	52	24	8	2	7	41	0	6	2	0	0	0	2	1	0	0	0	0	0	11
Nyström	50	18	8	0		26	2	8	2	5	5	0	1	0	0	1	0	0	0	22
Totals	1,239	492	180	52	7	731	51	150	49	64	58	41	35	31	8	6	6	6	3	457

*Not able to work; not bacilli free.
†Results not evident.

Ten or 5 per cent of our own and 182 or 14.7 per cent of the combined series were in this group after one year after operation. In the combined 10.9 per cent after two years.

The summary of the results in 8 series of cases totaling 1,239 cases is given in Table VII.

Of the total number, 731 or 59 per cent were living, 457 or 36.8 per cent were dead, 51 or 4.1 per cent were untraced. Of the living 67.3 per cent were in Group I; 24.6 per cent in Group II; 7.1 per cent in Group III; 9 per cent in Group IV. Of the 457 dead 32.8 per cent of the total number died within the first eight weeks after operation; 24.7 per cent died from the third to twelfth months, 36.1 per cent during the next four years, and 6.3 per cent from the sixth to the nineteenth years.

In Table VIII are shown results similar to those in Table VII except for lack of details as to time of postoperative deaths in another combined group.

TABLE VIII

SUMMARY OF RESULTS ONE OR MORE YEARS AFTER OPERATION

AUTHOR	CASES	LIVING I	II	III	TOTAL	UNKNOWN V	TIME OF DEATH AFTER OPERATION	TOTAL
Sauerbruch	701	179	247	30	456	38	1st-4th wk. 93; to 2nd yr. 63; later 51	207
Thearle	242	80	51	4	135	10	1st wk. 23; later 74	97
O'Brien	237	85	82	26	193		1st-8th wk. 14; later 25	44
Gravesen	179	50	31	7	88	1		90
Matson	150	70	36	9	115		1st-8th wk. 9; later 26	35
Kinsella	148	69	21	9	99		1st-8th wk. 20; later 29	49
Hegner	111	36	32	10	78		1st-8th wk. 19; later 14	33
Lambert & Berry	100	27	21	7	55	5	Postop. 24; later 16	40
Eloesser	100	34	9	10	53	22	1st-8th wk. 3; later 22	25
Casper & Bruns	92	26	21	4	51		1st wk. 8; 2nd wk.-3rd mo. 13; later 20	41
Archibald	78	20	35	0	55		1st-8th wk. 6; later 17	23
Alexander	78	32	4	19	35		1st-8th wk. 17; later 6	23
Jessen	69	34	12	11	57		1st-8th wk. 8; later 4	12
Davies	46	14	6	10	30		1st-8th wk. 5; later to 4th yr. 11	16
Eizaguierre	41	9	9		18		1st-12th wk. 4; 12th wk. to 1 yr. 6; later 13	23
Beye	38	18	11	1	30		1st-8th wk. 5; later 3	8
Sachs	36	19	9	1	29		1st-2nd wk. 4; 3rd wk. to 2 yr. 3	7
Piotet & Urech	31	2	16		18	7	1st-3rd wk. 4; 7 mo. to 2 yr. 2	6
Dolley	26	22	1		23		1st-8th wk. 2; later 1	3
Bettman	20	14	1		15		1st-8th wk. 3; later 2	5
Totals	2,523	840	655	158	1,653	83		787
Per cent	33.5		25.9	6.2		3.3		31.1

Among 2,523 patients, 1,653 (65.5 per cent were living at the time of the reports; 83 (3.3 per cent) were untraced; and 787 (31.2 per cent) were dead. Of the living, 50.8 per cent were in Group I; 39.6 per cent were in Group II; and 9.5 per cent in Group III. The higher propor-

tion of patients living in the series in Table VIII is doubtless due to the fact that these patients had been followed a shorter period of time.

Combining the results of Tables VII and VIII as shown in Table IX, we have 3,762 patients showing 63.4 per cent living, 3.5 per cent untraced, and 33.0 per cent died.

TABLE IX

SUMMARY OF ALL CASES

	TOTAL CASES	I	II	III	IV	TOTAL	UNKNOWN V	DEAD 1ST 8 WK.	2-12 MO.	1-14 YR.	TOTAL
Table VII	1,239	492	180	52	7	731	51	150	113	194	457
Table VIII	2,523	840	655	158	0	1,653	83				787
Total	3,762	1,332	835	210	7	2,384	134	150	113	194	1,244
Per cent		35.4	22.1	5.5	0.2		3.5				33.0

Of the total number operated, 35.4 per cent were clinically cured, 22.2 per cent improved, making a total of 57.5 per cent relatively favorable results, during a period of observation of from one to eleven years. If the number of deaths from causes not connected with the operation or extension of the tuberculosis is subtracted, the proportion of favorable results is very much greater.

For purposes of comparison the results of thoracoplasty in 1,159 cases collected from the literature and published in 1926, by Alexander and those of Sauerbruch in 1930 among "about 1,200" from his own clinic are of interest. Alexander found 36.8 per cent clinically cured, 24.2 per cent improved, 5.25 per cent unchanged or worse, and 33.5 per cent were dead. Sauerbruch reports 40 per cent of clinical cures and the combined early and late mortality 12 per cent to 23 per cent.

Many important series of cases reported since 1926 have not been included in the compilation of tables because the material did not lend itself to the classification adopted. Among such series may be mentioned the following: Neumann—100 cases with marked improvement in 40 per cent. Hauke reports 200 cases of thoracoplasty of which 40 per cent of the patients were clinically healed and able to work, 35 per cent improved; the "early" operative mortality from 4 to 8 per cent; the later mortality "months to years," 10 to 20 per cent. Gear's 75 cases: operative deaths during two months, 9 to 16 per cent; later deaths from progress of the tuberculosis, 24 per cent; "not doing well," 24 per cent; well, 30 to 40 per cent. Piotet and Urech operating through a special incision had a 13 per cent operative mortality. Two patients died later; 65 per cent were greatly improved or cured during a period of from one to seven years' observation. Johns reports 100 cases. Maurer and Rolland report 42 cases with 3 deaths in third week, Wangensteen 61 patients with 10 hospital deaths.

The degree of rehabilitation of the patients who are clinically cured is attested by the fact that a large proportion of the patients are able to and do resume their former occupations or lead the kind of lives they did previous to their illness. Among our own patients the following is a list of the occupations in which they are now employed.

OCCUPATIONS OF PATIENTS REHABILITATED BY THORACOPLASTY

Housewife	23	Business	15
Detective	1	Maid	1
School-teacher	2	Cashier	1
Housework	6	Politics	1
Clerk	5	Saleslady	2
Attorney	2	Laborer	4
Farmer	2	Chemist	1
Nurse	1	Dentist	2
Bank clerk	1	Hotel clerk	1

One of our patients developed an extensive pneumonia a year after operation from which she entirely recovered. The use of an oxygen tent is believed to have contributed to her recovery. One had a nephrectomy for tuberculosis of the kidney; one, a colored woman, had a hysterectomy for fibroids. All these patients have remained well. Several of the patients have married since their recovery; one has recently given birth normally to a baby, and both mother and child are well.

Bull records 10 pregnancies with the birth of living infants in 7. One patient died during the eighth month of pregnancy. Jessen, Lambert and Miller, Berard and Dumarest and Haymaker each reports one. Hofbauer reports one woman who had a baby and who remained well for a period of eight years after operation. Busch records 2; one of them at the time of childbirth had a persistent fistula from an empyema complicating the pulmonary lesion. Kinsella has 6 "thoracoplasty babies" in his series, two of three mothers having had two babies each since operation, all women remaining well. One woman reported by Saye had a thoracoplasty during a third pregnancy, went to term and had a normal baby.

As discordant notes as to the results of thoracoplasty may be mentioned those of Orszagh, who records 29 deaths among 66 cases, and of Wiener and Fishberg who had 9 per cent postoperative and 30 per cent later deaths; 15.9 per cent still in the hospital from two to ten years after operation, 31.8 per cent were still under treatment in clinics, not able to work because of active or chronic tuberculosis. Thirty-four of 44 who survived received no benefit from the operation; some bled after operation who did not bleed before; the idea of thoracoplastic closure of cavities they consider "illusory." Of 10 patients with empyema who had thoracoplasty 4 were dead, 2 still in the hospital very ill; 3 still have draining sinuses, one was well enough to work at the time of this report. In commenting on this report, which is so utterly divergent

from those reviewed, it may be said that while there is no reason to doubt that these authors' experience is as they state, it is unique. Furthermore, even though it is difficult to prove in any given case of tuberculosis treated by thoracoplasty that the patient might not have gotten well without it, this cannot be said of tuberculous empyema. In contrast as to the results of the treatment of empyema may be cited the authors' experience of 36 cases here reported with 50 per cent of complete healing.

PARTIAL THORACOPLASTY

Partial thoracoplasty may be defined as consisting of the resection of longer or shorter segments of seven ribs or less. It may involve the first two stages of an ordinary three-stage thoracoplasty or the resection of very long segments of the upper ribs only, including the full length of the upper one or two. Such a resection resulting in a drop of the apex of the pleural cavity to below the level of the clavicle in front and the fourth rib behind has been performed routinely by the authors as a part of the total resection, whenever an extensive collapse seemed indicated, particularly for a very large upper lobe cavity. If the lower part of the lung seemed relatively uninvolved and symptoms subsided and bacilli in the sputum disappeared, the resection was carried no further. In some cases the additional resections of shorter segments of the fifth to the seventh sufficed to make the patient symptom free. Many other surgeons working in this field have adopted this procedure. In 1928, Graf reported 9 cases operated by this method which he called "selective thoracoplastic collapse" with very good results and in 1930 writes that he had removed the whole first rib in 40 cases without bad results but through a combined posterior and anterior approach. The authors always perform the operation through a low paravertebral incision which does not extend around the lower end of the scapula. The secret of an approach is lifting the scapula away from the chest wall and the use of a long periosteal elevator.

Loescheke and Rost limit the resection to the first rib, preferably with additional division of all the scaleni. Rost states that Wilms' cases so operated showed 34 per cent of clinical cures. Roux has described a special incision along the seventh rib for resecting the upper seven ribs.

The evaluation of final results of limited partial thoracoplasty is not possible at this time because too few cases have been followed sufficiently long to establish them. Comparison of results is also impossible because of lack of details in most reported series as to the extent of the resection. Late results in a few reported series are given in Table X. Of the 236 cases, 87.2 per cent were living; 12.8 per cent died. Half of the deaths

were in the first eight weeks after operation. Of 175 living followed more than two years, 53 per cent were symptom free and without bacilli in the sputum.

TABLE X

RESULTS OF PARTIAL THORACOPLASTY

AUTHOR	YEAR	CASES	LIVING				TOTAL	UNKNOWN	DEAD		TOTAL
			I	II	III	IV		V	1ST 8 WK.	LATER	
Dolley	1934	59	49	1	0	4	54	0	2	3	5*
Eloesser	1934	39	14	3	5	11	33	0	1	5	6*
Coryllos	1934	26	23	3	0	0	26	0	0	0	0
Key	1930	20	10	4	2	0	16	0	1	3	4*
Uhlenbruck	1931	17	9	0	5	3	17	0	0	0	0
Hegner	1934	19	6	5	0	0	11	0	7	1	8*
Hegner	1934	18	2	13	0	0	15	0	2	1	3
Jessen	1930	15	9	3	1	0	13	0	1	1	2*
Domanig & Denk	1931	13	2	2	1	6	11	0	1	1	2
Kinsella	1934	10	6	1	3	0	10	0	0	0	0*
Totals		236	130	35	17	24	206		15	15	30

*Two years or more after operation.

Neuhof has added an extrapleural stripping to the partial thoracoplasty in cases with much thickening of it over the cavity. Among 24 cases of partial thoracoplasty there was one death; 10 were discharged with collapsed cavities and bacilli free, the others awaiting further operation. Thomsen has done 12 cases without complications.

SUMMARY

The surgical treatment of pulmonary tuberculosis includes paralysis of the diaphragm, division of the scaleni, partial and total posterior and anterolateral thoracoplasty and pneumolysis with plombage, singly and in various combinations. The indications as followed in different clinics and the technical details vary in important respects. Results obtained by different surgeons are therefore not strictly comparable but they do furnish the basis for a perspective of what has been achieved.

This study concerns itself chiefly with total posterior extrapleural thoracoplasty but also includes available reports of partial thoracoplasty. The authors' own 200 cases and a number of series totaling 3,672 cases of thoracoplasty reported since 1926 and which give comparable details furnish the material for it. It includes also 236 cases of partial thoracoplasty. The results are studied with special reference to early and late mortality, causes of death and duration and degree of improvement or of rehabilitation.

From one-quarter to nearly one-half the deaths within a period of from five to ten years occur within the first eight weeks. The authors' mortality in this period was 10.3 per cent; the combined mortality among 2,810 cases was 10.5 per cent. The individual variations among the series was from 3 to 20 per cent. The most frequent cause of death in

the authors' experience was cardiac failure and pulmonary complications. In a combined group of 230 deaths it was reported to have been due to shock in 8 per cent; heart failure in 18 per cent and pulmonary complications or extension of tuberculosis in 34 per cent. The mortality rate decreases progressively after the first few weeks. From one-half to two-thirds die during the first six months.

Among 3,762 patients followed for from one to twelve years after operation 35.3 per cent were free from symptoms and bacilli and were able to work; 22.1 per cent were improved and able to do some work; 5.5 per cent were not improved or were made worse by the operation; 3.5 per cent were not traced; 33.6 per cent were dead at the time of the report. A large proportion of the patients were rehabilitated to the extent that they were able to return to their former stations in life and to resume their former occupation or activities. Many women married and there is record of 22 who have borne children since their operation, usually against advice.

The variation in extent of partial thoracoplasty and the relatively limited number of any one type followed for one or more years make any estimate of enduring results from them inconclusive. Among 236 collected cases followed for two years or more 87.5 per cent were living; 12.5 per cent were dead. Of the living, 53.4 per cent were reported as clinically well; of the deaths one-half occurred during the first eight weeks after operation.

CONCLUSIONS

The surgical treatment of pulmonary tuberculosis offers to properly selected patients not suitable for pneumothorax therapy the best if not the only prospect of a complete arrest of the disease and when that cannot be achieved, of relief of symptoms and prolongation of life.

The proper selection of the patients and of methods and of the most opportune time for operation demands the closest collaboration of the phthisiotherapist and surgeon.

From one-quarter to one-half of the total deaths during the first ten years following thoracoplasty occur during the first eight weeks and are due largely to shock, cardiac failure, and pulmonary complications, all in considerable measure preventable through preoperative preparation, through operation graded into stages according to the patient's condition, and watchful prolonged postoperative supervision. Such measures will extend indications for operation. Even though by so doing the total mortality is not reduced more, patients otherwise hopeless are given the chances it affords.

Deaths after the first eight weeks are due largely to extension of the tuberculosis, in some measure preventable through primary adequate

collapse, through secondary additional collapse or compression for recurrence and through reasonable care of health.

Adequate application of the method or combination of methods indicated, early in the disease before extensive destructive changes in the lung and before secondary visceral damage has occurred will result in a minimal mortality, a maximal conservation of respiratory function and in the greatest possible measure of rehabilitation.

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DISCUSSION ON: "THORACOPLASTY IN BILATERAL CAVERNOUS TUBERCULOSIS," BY DR. JESSEN; "SIMULTANEOUS BILATERAL ARTIFICIAL PNEUMOTHORAX IN THE TREATMENT OF PULMONARY TUBERCULOSIS," BY DRS. KINSELLA AND MATTILL; "THORACOPLASTY VERSUS PNEUMOTHORAX," BY DR. CORYLLOS; "SCALENIOTOMY WITH OR SUBSEQUENT TO PHRENICECTOMY IN THE TREATMENT OF PULMONARY TUBERCULOSIS," BY DR. FISHER; "THE RESULTS OF OPERATION ON THE PHRENIC NERVE," BY DR. LAMBERT; "THE RESULTS OF THORACOPLASTY IN PULMONARY TUBERCULOSIS," BY DRS. HEDBLOM AND VAN HAZEL.

DR. O'BRIEN.—I wish to express my appreciation of the splendid paper of Dr. Jessen. I think he has given us a lot to think about. I do not believe, however, that I can quite share his optimism regarding the closure of cavities with bed rest alone, nor can I feel that one can always tell whether a cavity has a soft or a thick wall from either x-ray or physical findings. I think it is a little bit dangerous to attempt this classification unless you see the cavity developing.

I have seen many cavities which appeared to have soft walls but which could not be closed even with a complete thoracoplasty or with the maximum collapse of artificial pneumothorax. Pinner's classification of cavities helps us a lot, but it is not infallible. I bring this out merely because I feel that if we try more simple procedures than thoracoplasty on many of these lesions, which appear to be thick-walled cavities, we often will get results that will obviate the necessity of upper-stage bilateral thoracoplasty which he does so frequently.

In my experience, the early application of pneumothorax or phrenic nerve operations, either unilaterally or bilaterally, or phrenic nerve operation on one side with pneumothorax on the other, combined when necessary with the use of unilateral thoracoplasty will control most lesions without the necessity of bilateral thoracoplasty. I personally have never performed a bilateral thoracoplasty, but, of course, would not hesitate to do so if the cavities could not be closed and the lesions controlled with less drastic measures.

I agree with Dr. Jessen regarding plombage. I do not believe that it is a scientific procedure. What we are accomplishing is not compression, but relaxation. This procedure is inexact and therefore seldom used in the clinic.

Dr. Coryllos, I am afraid, is hopeless. (Laughter.) He is either blindly prejudiced or at least unfair to phrenicectomies. He does not believe in doing phrenicectomies early when he could expect results from them, but waits until the lesion becomes a thoracoplasty lesion, and then does a phrenicectomy and is discouraged because he does not get a result. As a result of this long protracted wait, during which he is hoping that the cavities will close by themselves, the thoracoplasties when performed are performed too late. He is always behind. He will never catch up unless he changes. He will never get the results from phrenicectomies that we and other people get because he does not do them early enough. He will never get the results from thoracoplasty because his patients will, of necessity, have a chronic thick-walled cavity which is difficult to close.

Regarding scaleniotomy. I never could feel that this procedure could accomplish closure of cavities of any size. When one remembers that removal of the entire first, second, and third rib from the transverse process to, and including, the cartilages will close only a small percentage of small cavities, it is hard to visualize just how cutting the scalene can cause this closure. Evidently Dr. Fisher's experience is somewhat different, but I still feel that indications for this operation are very limited.

Dr. Lambert presented the subject of phrenicectomy, I think, very fairly, and exactly as it is. I agree with him that statistics should not be presented. I think that these can be compiled only if one waits too long to see what the results of a phrenicectomy might be instead of adding pneumothorax early if immediate results are not obtained from the phrenic operation. I think if we will all get over this idea of comparing results of phrenicectomy, pneumothorax, and thoracoplasty, putting one against the other, and all believe in collapse therapy with whatever measure or combination of measures necessary to cause early closure of cavities, we shall begin to give patients better treatment. I think we should buy health as cheaply as possible, and should start with the simplest procedures, and then add more drastic measures when it seems that the simple measures will not accomplish the desired result in a short time.

All these procedures accomplish the same thing to a varying degree. Coryllos says he never uses phrenic nerve operations. How can one treat tuberculosis adequately without the use of a procedure which will give some reduction in lung volume and some added rest to the lesion? Surely, we have all degrees of lesions—small, minimal, moderately advanced, and advanced. If he does not do a phrenicectomy on a minimal lesion, he must either do nothing or give pneumothorax to a lesion which could be controlled with more simple procedures, such as phrenicectomy. When adhesions complicate pneumothorax, the use of phrenic nerve operations is indispensable, and if he does not use it here, he is depriving his patients of a very valuable adjunct to their treatment. We should buy health, as I said before, as cheaply as possible. If a simple crushing of the phrenic nerve will do it, well and good; if a phrenicectomy is necessary, perform that, or when necessary, go on to a pneumothorax or a thoracoplasty.

I do not agree that it is dangerous or wrong to do a thoracoplasty for a soft-walled cavity. I have not found it so. If a cavity, apparently soft-walled, cannot be closed with a phrenicectomy, I think, as soon as this is determined, a pneumothorax should be added, and if this cannot close it, a thoracoplasty should be done immediately. That cavity is still open, and is still a menace to the patient as long as it is open. I see no reason for waiting, and sacrificing thousands of patients in the hope that some few might get well without this procedure.

Dr. Hedblom's statistics were very interesting. I think, however, that it would be better if we looked at the results of thoracoplasty as we are doing it today rather than at the way we did it in the old days with the now obsolete methods. All of us have gone through a period of evolution where we used various technics, etc., and I believe patients should know what they can expect at the present time.

A year ago, I reported 63 patients with the complete removal of the upper three ribs, with 83 per cent negative sputum, and 92.8 per cent closed cavities. This year, one year later, 89 per cent of those same patients are now negative, which catches up almost to the closed cavities. Only one patient in that group has died, and that from insulin shock. From April of last year to April of this year, I have operated on 88 patients. In those, 81 per cent now have negative sputum, and 91 per cent closed cavities, but the 91 per cent closed cavities includes those that were operated on in January, February, and March. We have not finished the number of stages that we expect to do. In those in whom we have finished the stages that we expect to do, 96.9 per cent have closed cavities, which compares very favorably with Fishberg's findings, since he said he has never had one closed cavity in all his experience.

I just want to add one thing about spontaneous closure of cavities. It is my experience, and I think it is the experience of every one, that cavities close when you close them mechanically. You can take an enormous cavity, 6 or 7 cm. in diameter, reduce it to 1 or 2 cm., but this remnant seldom closes. Nature cannot

close this small remnant of its own accord, in the majority of instances, and still many people claim that it will close the large, original cavity.

I might add that the mortality rate in this group last year was 1.6 per cent. It is now up to 2.6 per cent. That is from a group of 151 patients.

DR. LILIENTHAL.—It seems to me that these discussions have been too much from the purely surgical side and that our nonsurgical members might well take a more prominent part. Early in my work in tuberculosis I was convinced by roentgen evidence in a case which had gone on for years with resulting clinical and radiographical cure that the surgeon should not be anxious to operate if an expert phthisiologist believes that nonoperative treatment may give equally good results.

Dr. Fisher has given us a convincing argument for scaleniotomy. I have had no experience with this operation.

Finally comes the selection of the patients for operation in the presence of complicating diseases. I maintain that unless it is pretty certain that the patient cannot survive his complicating disease there is no reason why his tuberculosis should not be treated by operation.

DR. COLE.—I wish to pay tribute to our distinguished guest, Dr. Jessen, whose optimism I share. We have had an experience not unlike his with comparable results and I wish to discuss this from an internist's viewpoint.

We have done many bilateral surgical procedures without great difficulty and with but few complications. One of these was bilateral upper thoracoplasty with a good result. We are convinced that bilateral selective collapse is practical in properly selected cases. We have had relatively few bilateral pneumothoraces, but our experience with this procedure extends over the past ten or eleven years.

We have long believed that the optimum benefits to be obtained from surgical collapse come from closure of cavities, and whatever surgical procedure best accomplishes this should receive first consideration. Using this procedure, we have been enabled to free practically all these patients of tubercle bacilli and get the majority of them sputum free.

We have had no experience with scaleniotomy, but it looks like a rational proce dure, since any lessening of the size of the thoracic cage will permit greater lung relaxation or contraction, and thus aid in the closure of cavities. We feel that the size, location and thickness of the cavity wall are major factors in the procedure necessary for closure. All of us who study chest x-ray films have seen many cavities that have healed through fibrosis and calcification, which never close until, if and when, fibrous tissue and calcium are sufficiently absorbed to relax or soften the cavity wall.

For several years we have greatly increased our collapse by pneumothorax, and since doing this we have found continuously lessened indication for radical surgery. I believe if pneumothorax is properly utilized indications for total thoracoplasty will greatly diminish, and the field for selective or localized thoracoplasty broaden.

For instituting pneumothorax for the past few years we have been using a blunt needle which I learned of through the courtesy of Colonel Bruns. Since adopting this needle for our initial deflation we have had but few failures. This has also enabled us to utilize pneumothorax with many patients in whom we would not otherwise consider this procedure.

Several years ago we reported that in our experience paralysis of the diaphragm seems contraindicated where partial upper lobe thoracoplasty is done for closure of cavity. We find that the pulling of the diaphragm is helpful in this type of cavity closure, and not contraindicated as has been suggested. We also find diminishing indications for permanent phrenicectomies.

DR. JOHNS.—I wish to express my great appreciation of the paper presented by our distinguished guest.

Five years ago, I presented before this Association a report of our results with selective collapse surgery. We had a limited number of cases at that time; numbering, to date, 45 cases.

We are increasingly enthusiastic about selective collapse therapy, and have found few apical cavities that we could not close by a sufficient resection of the upper thoracic cage. If the cavity was large, we have removed practically all of the rib; and if a sufficient collapse was not then obtained, we have done an anterior resection.

We have done fewer operations on the phrenic nerve each year. In apical lesions a phrenicectomy is rarely indicated. Dr. Lambert's paper on this subject is very timely, and I am thoroughly in accord with what he has said.

DR. ALLEN.—We have all been very much benefited by this morning's discussion. I have been especially interested in the paper of our distinguished guest, Dr. Jessen.

Two years ago I reported before this society the first case of bilateral, partial thoracoplasty for pulmonary tuberculosis. I am glad to say that the patient has continued to be well.

Since that time we have started bilateral, partial thoracoplasty upon five patients, three of which have been completed. Of the other two patients, one is at the present time clinically well and the other is improved.

Dr. Jessen gave a series of indications for operability in these cases with bilateral involvement. I should like to add one indication, which I think is of extreme importance, to the list that he mentioned. I refer to the adequate vital capacity of the lungs. You all know that the normal vital capacity of the lungs is between 3,000 and 5,000 c.c. The air required by the average patient or by the average individual is about 500 c.c. at each inspiration.

Now, a patient with a vital capacity of 800 c.c. (the maximum volume of air that he can get into his lungs) is, obviously, a poor risk for any type of collapse therapy.

I noticed in Dr. Hedblom's figures a high number of cases the deaths of which were ascribed to heart failure. I am firmly convinced that many of these cases die not of heart failure, not of failure of the myocardium, but rather of anoxemia due to an insufficient vital capacity remaining after their operation.

Dr. Jessen mentioned aspiration as one of the dangers. It does not seem to me that aspiration is any more likely to be a factor in bilateral procedures than in unilateral. As a matter of fact, during the last seven years in my cases at the Koch Hospital, in St. Louis, we have not had a single case of postoperative tuberculous pneumonia. In going over the possible reasons for this, it occurred to me there might be an explanation. Of necessity, I am forced to operate on these patients in the afternoon. You all know that patients with tuberculosis have most of their expectoration in the morning, or, at any rate, a great percentage of them will clean their lungs by noontime.

I believe that the low incidence of postoperative tuberculous pneumonia in my cases is due, at least in part, to the fact that I am operating upon patients whose lungs are clean and they are cleaner than one can obtain by placing the patient in posture for a half hour, or an hour, before operation.

Dr. Coryllos mentioned that one could take three or four ribs on both sides with safety. Dr. Thomas Kinsella has, in some experimental work reported several years ago, removed as many as seven ribs and in one instance nine ribs on each side from monkeys and found that the animals lived quite normally.

I think the thing that we should use to guide is again the vital capacity. A patient with a vital capacity of 2,500 c.c. can have more ribs removed than a patient with a vital capacity of 1,000 c.c.

Dr. Graham has taught us the essential thing in considering the operability of these patients, and that is that, after all, a patient's breathing apparatus, his chest, is one organ and not two. To me, removal of portions of half of the upper ribs from both sides is almost the same as removing portions of all of the ribs on one side.

DR. ARCHIBALD.—I particularly want to say something about the paper of our guest, Dr. Jessen. I am extraordinarily pleased with that paper. I am sure that I voice the opinion of all of us when I congratulate him not only upon the excellence of his address, but also upon the excellence of the manner of its presentation—the way it was put down, the style of it, and his own command of English. I could not help wondering how many of us here could stand up before a German Congress and express ourselves in German as well as he did in English.

As to the actual question of bilateral thoracoplasty, I count it rather curious, in a way, that I have not had, so far, a good opportunity of doing a bilateral thoracoplasty. It may be that I have allowed certain opportunities to slip, although I have been prepared to do it for years. In fact, I recommended it seven or eight years ago for a patient whom I saw in consultation in Minneapolis. It was a case of bilateral cavity, measuring, as I remember, about 5 or 6 cm. on each side. That patient, I believe, ultimately died after the operation, but whether the first or the second, I do not know.

I believe I had the reputation some years ago of presenting too good statistics because of the fact that I chose my cases too well, too exclusively. That was not the case. As a matter of fact, it was because in the earlier years I had a group of sanatorium men who chose them for me, whereas now these same sanatorium men tell me they have run out of all their good cases, they have used them all up; I suspect they still have good ones but give them to "the young man," and send me the bad ones.

It is perfectly obvious that there must be a large number of bilateral apical cases, in which thoracoplasty should be done, where phrenicectomy must necessarily fail on account of the pathologic conditions and where artificial pneumothorax is insufficient.

Our recourse is naturally to a bilateral upper thoracoplasty. As long as we held to the old dictum of Sauerbruch, that a total thoracoplasty ought to be done, even when the lower lobe was sound, we could not consider that sort of thing. That early contention of his is not yet entirely discarded but is now rather widely disputed. I disagree with it and I think we all do. In one sense, his leadership at the time was sound, but for the present day it is unsound. We now accept the principle of a limited operation for limited disease. But the limited operation as to number of ribs must still be thorough, even total, within those limits.

Dr. O'Brien, I think, has pushed that principle to its logical conclusion when he insists for upper third involvement with sound lower lobe, upon a total removal, from the transverse processes to the cartilages (or even including the cartilages) of the upper three ribs, with somewhat shorter resections of the next three ribs. His operation, I think, is narrowing very seriously, and I think advantageously, the field of the anterolateral thoracoplasty.

We are ourselves trying this out. I feel sure, for my own part, that Dr. O'Brien has the correct principle, and the figures which he gives us here are very impressive.

If I may be allowed, I should like to discuss that particular point even though it was a point raised in the discussion and not by one of the original papers. The

point is this: Dr. O'Brien says that he does not hesitate to operate on "soft" cases. Well, of course, I am afraid of operating on soft cases. But I think the difference between us may be represented by a differing conception of the extent or character of the disease. I always think of a soft lesion as being in reality a soft *clinical* lesion, not merely an x-ray lesion, or stethoscopic lesion, but a clinical lesion. I always deprecate any limited view of any case. The soft lesion should not be referred to as a soft lesion. One should speak rather in terms of resistance. The patient with a "soft" lesion should be referred to as a patient who has lost resistance, whose disease has spread quickly or is exudative in type, the type that Dr. Jessen referred to, as I understand, as being the third degree of allergy. In such cases I have had too much experience with thoracoplasties provoking contralateral and homolateral spread not to be afraid of it.

I must not take too much time, but there are one or two points in the other papers that I should like to refer to. Dr. Coryllos' contention that after phrenicectomy (or before!) thoracoplasty should be undertaken without delay (and be repeated "without delay" frequently) I thoroughly agree with. I do feel, still, that artificial pneumothorax should be the first thing to try. It has such obvious advantages. But an incomplete pneumothorax is unsatisfactory, as has been known for many years, ever since the figures given us by Saugmann and Gravesen. An incomplete pneumothorax is a dangerous thing. If left with it, patients go on to die. They should be "without delay" submitted to thoracoplasty. A certain number of these, of course, will be helped by phrenicectomy and by Fisher's scaleniotomy.

I must congratulate Dr. Fisher on the extremely good paper which he presented. The outstanding characteristic seems to be modesty and honesty. I think we now have some proper line on what can be expected from scaleniotomy in the selection of cases.

I agreed entirely with what Dr. Lambert said, that, as regards the phrenicectomies, we have to make the indications more precise. Nevertheless, however curious you may think it, I also agree with Dr. O'Brien's attitude. The difference is more apparent than real. It should be remembered that although Dr. O'Brien has done a lot of phrenicectomies, he has had a lot of material to do it on. His proportion of phrenicectomies may not be any greater than ours.

A year ago, if you will excuse a personal reminiscence, I was guilty of making a joke at the National Tuberculosis meeting, a joke which had repercussions undesired by me. I referred to the wave of phrenicectomy which had passed over the country as, so to speak, a crime wave. Now that was purely a joke, but I have heard since that it was misinterpreted.

Of course, this wave of phrenicectomy has in it 90 per cent of good. All that I plead for is more precise indications, and not to do it routinely or unthinkingly on patients who obviously are not going to be benefited by it.

There is no doubt in my mind that in doing phrenicectomies for soft cases, for exudative cases (and I like the term "exudative," or progressive, or "in the course of evolution," as the French say) I have certainly experienced several bad results in the way of spread. The patient has to be regarded from the standpoint of his vital resistance, or his energy, whatever that consists of. We are coming to estimate that resistance more accurately by means of the sedimentation rate, and the blood picture generally, but we are still better able to estimate it if we give enough care and thought and study to follow in detail that patient's history from the time his tuberculosis began until the moment when we see him; with the help of a long series of photographs and a long series of detailed reports. I must insist on the absolute necessity of more precise, more detailed clinical study. Only with that, can we estimate the patient's resistance so that we shall be able to judge the effect of our operations.

Undoubtedly, we have to accept, as Dr. Lilienthal said, a number of patients who are not in good condition. We must take risks. For that reason I, for long, following Brannel, have urged the dividing of cases into three classes, in the expectation of getting greater precision of selection. General figures, all including, are liable to be deceiving, as being either too discouraging or too encouraging. Risks should be divided into classes if we are to be able to give the individual patient a rational prognosis in respect to a proposed thoracoplasty.

DR. HAROLD JESSEN.—I want to thank you for the very kind words that Dr. Archibald said about my English. I do not feel at all a master of this language, and I beg you to excuse all the faults I have made and the faults I will make still.

I hardly dare to take part in this discussion because my little knowledge of the English language may help me to make some mistakes. I understood Dr. O'Brien to say that soft cavities must not be operated on. I think he means by that that only through surgical help are we able to close a cavity.

I enjoyed, very much, what Dr. Lilienthal said, that in tuberculous disease there always must be common work between the physician and the surgeon. Tuberculosis cannot be considered as a purely surgical disease. It is quite impossible to do that. We, who work in climatic places, are used to seeing many good results without any mechanical help.

I think that all our surgical treatment does not mean more than giving some help to the organism. I must beg Dr. O'Brien to realize the fact that it is not the surgical work which cures a cavity, but it is nature which cures the cavity. What we do is nothing more than to prepare the conditions, the mechanical and biological conditions, which allow that cavity to be cured. Of course, it must be confessed that this aim can be reached also by nature itself.

I want to mention the very grand paper that Dr. Hedblom has given us and to say that we learn a great deal from our failures. I believe that only this learning from our failures will give us a real judgment about the forces which live in an organism and which can help us in curing tuberculosis.

I am not sure, because I do not quite know the habits and practices in this country, and I might be considered a little odd if I try to make a little joke when I say, if I see these numbers of mortality then perhaps it seems possible that the judgment about the healing of cavities will change if this mortality becomes a little higher in the future.

DR. POL. N. CORYLLOS.—Dr. O'Brien has honored me by concentrating on me his rather fiery discussion on the usefulness of phrenic nerve interruption. I am a little surprised that he did since my doubts about the efficiency of this operation, when applied alone in the closure of cavities, were confirmed in every one of the papers read this morning.

I have repeatedly stated that I consider this operation when applied alone of little value; I have also repeatedly and persistently objected to the overoptimistic figures which Dr. O'Brien has been publishing for several years, and I have warned against the disasters that his great enthusiasm is liable to cause and has caused; these disasters are due either to the loss of precious time for the patient while we wait and hope that cavities will close as a result of the operation (which time often exceeds several months) or to the attempt by surgeons of insufficient training to try this miraculous operation.

Personally I have only 3 closures of cavities in 200 phrenicectomies while Dr. O'Brien has obtained as many as 90 per cent in moth-eaten lesions. This morning I asked Dr. O'Brien to give me his actual figures. He answered that he had no

definite figures, although he has performed over 4,000 phrenicectomies; because he said, when phrenicectomy, which is performed routinely upon almost every patient entering the sanatorium, did not cause closure of the cavity within a few weeks he did not wait but performed some other collapsing operation. This sounds peculiar and somewhat contradictory to previous communications of this author; furthermore, it is surprising that although this morning he gave us his results in some 150 thoracoplasties expressed in figures with one or even two decimals, Dr. O'Brien is unable to offer definite figures on an operation which he has performed on over 4,000 patients.

The question of phrenicectomy is of vital importance to all of us interested in the surgical treatment of pulmonary tuberculosis and to the profession at large. Therefore I welcome this opportunity to answer at length the points raised by Dr. O'Brien.

Let us first remind O'Brien that four years ago and again last year he presented definite and concrete figures of his results in phrenic nerve interruption. In his paper on "Phrenic Nerve Operation," which appeared in the *Journal of the American Medical Association* (August 30, 1930) he published the following figures (p. 651):

1. Results obtained with phrenicectomy alone and combined with pneumothorax:

Patients with cavities in which pneumothorax was not tried, cavities closed with phrenicectomy 62.7 per cent.

Patients with cavity in which pneumothorax and phrenicectomy were combined, cavities closed 70.8 per cent.

2. Results of phrenicectomy with unsuccessful pneumothorax:

Cavities closed	50.0%
Cavities became smaller	42.8%
Cavities unchanged	4.8%
Cavities become larger	2.4%

3. Results of phrenicectomy in different types of cavity:

Thin-walled cavities closed	58.8%
Thick-walled cavities closed	7.1%
Moth-eaten cavities closed	90.0%

4. Results of phrenicectomy according to location of lesions:

Cavities in upper lung field closed	46.6%
Cavities in middle lung field closed	62.5%
Cavities in lower lung field closed	80.0%

In summing up this author says (p. 651), "of the series here reported 378 patients were operated on for cavitation. In 191 of these patients or 50.5 per cent the cavities closed following operation. In 31.2 per cent they became smaller. Therefore about 82 per cent of the cavities were either closed or reduced in size." It is clearly indicated in Table 2 (Table 4 of Dr. O'Brien) that these results were obtained with phrenicectomy alone.

It seems to me that these are rather precise figures, and I am at a loss to explain his hesitation this morning to corroborate these figures.

On the other hand, it is of interest to point out a number of fundamental differences of opinions among the authors who uphold phrenicectomy.

Nehil and Alexander, in a more recent paper published in this JOURNAL (2: 549, 1933) report that in moth-eaten cavities they had closure of cavities in 27 per cent whereas O'Brien reports 90 per cent; on the other hand Nehil and Alexander reported in cavities of the upper third of the pulmonary field 40 per cent closures (about the same as O'Brien who gives 46.6 per cent) whereas in cavities

of the lower field they had only 29 per cent closures against 80 per cent of O'Brien. These discrepancies of opinion are inexplicable to me, especially when we consider the surprising agreement between the figures given by the different authors concerning methods of collapse therapy such as pneumothorax and thoracoplasty. I think that these discrepancies may find an explanation in the following paragraph taken from Nehil and Alexander (p. 568): "Phrenic Operation," write these authors, "was added to an unsatisfactory pneumothorax in 116 of the 181 patients (mentioned above) because of the continuing presence of cavernous lesions. The addition of the phrenic paralysis resulted in complete closure of the cavity in 59 per cent (69 patients)." Every one would understand by this that 59 per cent of these cases were arrested; really it is not so, as the authors add: "the results in these 69 patients with closed cavities are 26 per cent arrested, 63 per cent improved, 6 per cent worse, and 4 dead." In other words, out of the 116 patients in whom phrenicectomy was added to pneumothorax only 17 were arrested, which is only 14.6 per cent, as compared to 59 per cent of Nehil and Alexander and 70.8 per cent of O'Brien.

Another important question is, how long should we wait after phrenicectomy for the closure of the cavity? From the paper of Nehil and Alexander one would surmise that the longer we wait the better it is as is shown in their following figures (p. 557):

"Results according to the length of postoperative observation."

3-12 months, arrested cases	15%
12-24 months, arrested cases	40%
24-36 months, arrested cases	57%
36-72 months, arrested cases	66%

However, the total percentage of arrested cases in the 272 patients upon whom the above table was based, within six years was only 34 per cent, and 35 per cent "improved"; if we consider that in the classification of these authors "improved" corresponds to the "apparently arrested" and "quiescent" of the classification of the National Tuberculosis Association (that is, patients with no constitutional symptoms, tubercle bacilli absent or present, roentgenologic evidence of stationary or retrogressive lesion and that these conditions must have been present for at least two months) we can reasonably conclude that we can well place these "improved" cases in the prospective list of deaths, and safely admit only 34 per cent as arrested cases.

Welles is, or rather was, also an enthusiastic supporter of phrenicectomy. He has lost a great deal of his enthusiasm, he has written me lately; since then Dr. H. Lynch of Saranac Lake, revising the results obtained in 80 phrenicectomies operated upon by Dr. H. Welles, has found only 7 cases of closure of cavities (private communication).

I could quote a great number of authors who are as skeptical as I am about the efficiency of phrenicectomy. Suffice it to quote only Sauerbruch who says (p. 1080), "of 185 patients on my service who had phrenicectomy alone 15 (9 per cent) are well and able to work."

For the reasons given above I have no faith in phrenic nerve exeresis, when performed alone. I believe that this operation is not efficient, not without danger and causes a loss of precious time.

It is my contention today that when the presence of a cavity is ascertained, the cavity should be closed and the sooner the better. It is harmful to submit the patient to a prolonged rest which gives only 17 per cent closures and 70 per cent deaths within five years. It is equally unreasonable to lose more time with phrenicectomy or apicolysis unless there are special indications for these operations. The

treatment of choice for cavities should be pneumothorax or thoracoplasty and our efforts should be directed to a better and more precise discrimination in the respective indications for these two procedures.

I no longer believe in the conception that we should first try in patients with cavities the so-called milder procedures such as phrenicectomy, intercostal neuronectomies, etc., and that only if they fail should pneumothorax or thoracoplasty be done. On the contrary, it seems to me more rational to apply as soon as possible the methods which have given us the highest percentages of cure; of these methods, thoracoplastic collapse has undoubtedly given the greatest ratio of cures.

I do not see why we should reason differently in tuberculous cavities than in any other surgical disease. Thirty years ago there were exactly the same discussions between "radicals" and "conservatives" in the treatment of appendicitis. Bed rest, ice bags and so forth have certainly cured a number of patients but have also unnecessarily killed a great number of them with peritonitis, abcesses, etc. We all agree today that a diseased appendix should be removed and the earlier the better. It is the same, I believe, with tuberculous cavities; since their closure is the only way at our disposal today of insuring the arrest of the disease, the sooner we do it the better for the patient; and the more effective the methods we use for that purpose, right from the start, the greater will be the number of patients we shall be able to save. The time element in tuberculous cavities is as important as in appendicitis; no one can predict what can happen tomorrow in a given patient. A hemoptysis can produce sudden spreads in apparently quiescent cases as dangerous as rupture of an appendix in an apparently quiescent case of appendicitis. Why then procrastinate?

It seems to me more important when we consider the results obtained with bed rest treatment, phrenicectomies, costal neuronectomies, etc., to consider not how many of our patients we cure with these methods but how many we lose. Then it will clearly be seen that the so-called "conservative" phthisiologists waste more human life than the so-called "radicals," and that the latter do not deserve the criticism of O'Brien and Lilienthal that they expose their patients to unnecessary dangers or that they "lose time" by not performing phrenicectomies routinely.

DR. LINCOLN FISHER.—I should like to thank Dr. Archibald and Dr. Lilienthal for their kind reception of my humble effort. It may be of further interest to note that of a series of 161 cases selected for phrenic nerve interruption alone from 1931 through 1933, at Waverly Hills Sanatorium, 40 per cent were definitely favorable in contrast to about 60 per cent favorable results in the series of 135 cases subjected to scaleniotomy with, or subsequent to, phrenicectomy. Also, 22 per cent of the cavities were closed, and in 33 per cent the sputum was rendered negative by phrenicectomy, in contrast to 35 per cent and 50 per cent, respectively, in the series selected for scaleniotomy. Both series contained many impossible or inefficient pneumothoraces.

I should like merely to emphasize that in our experience scalene section adds approximately 50 per cent to the effectiveness of phrenic operations. It is worth a fair trial in selected cases and also when pneumothorax fails, or thoracoplasty is contraindicated. While, of course, far from a panacea, it has proved to be a useful adjunct in a field wherein all aids are welcome.

DR. ADRIAN V. S. LAMBERT.—I have very little to add. I cannot help but pay my compliments to Dr. Jessen and assure him that one, at least, here derived more benefit from his paper than from any other. It is a joy to me, always, to see a man who has a broad conception of our occupation and is a doctor from his feet

up, and it is always, I believe, a helpful thing for all of us to have a man get up and emphasize the philosophy of medicine and raise this, our specialty, from a possible sinking to the level of glorified plumbers.

DR. CARL A. HEDBLOM.*—At this stage I want to say one or two things. Dr. O'Brien said that the total posterior thoracoplasty is an obsolete operation. I wish it were, but I am sure that it is not. It is one thing to wish to get the case early where the lesion is limited and where we can do a little operation, and it is another thing to get it. In the present state of surgical compression of tuberculosis in this country, I am sure that for many years to come there are going to be many patients for whom nothing less than the rather thorough collapse of the whole lung, with the addition of the anterolateral section, is going to be necessary before we get results.

As to the statistics, he stated that we should not talk about figures. How else are we going to measure the results of our work? Are we going to depend on impressions and remember only our brilliant cases and forget about our failures?

I quite agree, as Dr. Archibald has pointed out many times, that if you try to compare the results of a particular type of lesion treated in different ways, you have no basis for comparison and your conclusions are fallacious. But, given a certain type of patient and a certain type of treatment, there I feel that the only test of the procedure is the results that you get. As far as assaying the results of a newer procedure, we have to wait until sufficient time has elapsed to see what the later mortality is going to be. As Dr. Jessen intimated, before you can say this operation will give you such and such a result, you must find out those things. We have not that in the case of partial thoracoplasty, or at least only in a limited number.

I was interested in what Dr. Allen said about operating in the afternoon. A good many curious things come out, and that is one of them. I feel that we have still many things to learn about the general problems in this field.

Another thing in which I was very much interested, aside from the different mortality following resection on the two sides, was the observation that the mortality in the winter months was three times the mortality in the summer months. We went over our own results and found our mortality was to the contrary, three times as high in the summer as in the winter. Just why that is, I do not know. How we are going to determine what the facts are and what they depend on, I do not know except by a study on the part of a large group.

There is only one more point: In trying to evaluate results and in going over the literature, one is impressed with the extreme versatility and individual tendencies on the part of every man who writes a paper to put in a particular individual point that makes it difficult to compare his results to those of some one else. I think that the points brought out by Dr. Bull, at the International Congress in 1930, and the system of classification and the large amount of material that is already accumulated would, perhaps, justify the hope that possibly others will see fit to classify their results in the same way.

I want to say that in the study of our own patients and our own results we have learned a lot, and I am sure that we have learned more than we can hope to pass on to any one else.

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*Dr. Hedblom's death occurred before he had an opportunity to correct the stenographic record of his discussion. The editor has, therefore, made an attempt to revise it from memory of the remarks which Dr. Hedblom made.

NONPARASITIC CYSTIC DISEASE OF THE LUNG

Its Clinical Recognition and Treatment*

Emmet F. Pearson, M.D., Springfield, Ill.

CYSTIC disease of the lung has been known since Meyer's[1] description in 1858, but it attacted little attention in this country until 1925. The disease is still considered a pathologic rarity; although more careful diagnosis would probably reveal cases that are now receiving other diagnoses.

In the term *cystic disease*, we include here abnormal localized distentions of the various portions of the tracheobronchial tree, and other discrete sacs which apparently originate from the interstitial portion of the lung. The title includes voluminous and rapidly expanding air cysts in infants, large solitary cysts of stationary size, multiple cystic dilatations which communicate freely with bronchi, diffuse cystic change or "honeycomb lung," and pedunculated cysts. The cysts may contain gas or fluid of varied characteristics, and may or may not communicate with bronchi. The cyst wall may have the characteristics of bronchi, bronchioles, atria, infundibulae, or alveoli. Other cysts may have none of the architectural characteristics of the tracheobronchial tree. The latter are assumed to originate from faulty lymph anlage, and, therefore, are lymphangectatic. The greatest confusion exists between true cystic changes and so-called congenital bronchiectasis and localized areas of emphysema. True cysts are usually thought to be congenital in origin, but there is good evidence that some may develop postnatally from aberrant rests of primitive tissue, or after some form of obstruction causes a distention of a portion of the lung tissue distal to it.

The various theories regarding the etiology of congenital bronchiectasis and lung cysts of all types have been evaluated by Eloesser,[2] Anspach and Wolman,[3] Lilienthal,[4] Ballon, Singer and Graham,[5] and others. In a clinical discussion, these academic points are not of great importance. The clinical significance of a cyst once formed does not depend upon its method of formation.

Cystic disease has been extensively studied pathologically. Müller[6] in an admirable review of the pathologic studies concluded that a sharp distinction between congenital bronchiectasis, lung cysts, "honeycomb lung," small cystic degeneration of the lung, congenital vesicular

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changes, fetal atelectasis, bronchial and lung adenoma, and congenital pulmonary lymphangectasis is not possible.

Since Koontz[7] reviewed the literature in 1925, and found one hundred eight cases of so-called congenital cystic disease, sixty-four cases have been reported in readily available literature, twenty-two of these cases having been reported by American authors. Since these cases are selected because of the title under which they appear, the list of one hundred seventy-two cases which have been reported as cystic disease could be increased by including cases reported as bronchiectasis, local-

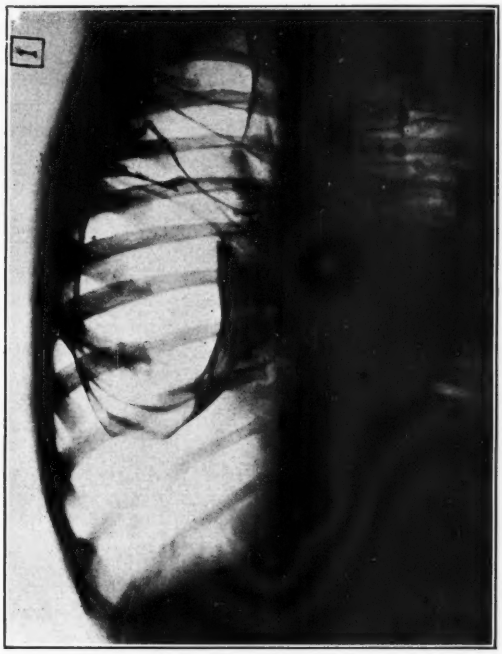

Fig. 1.

ized emphysema and pneumothorax, which, from description, are identical with other cases reported as cysts.

In the past five years we have observed eight patients in the Chest Service of Barnes Hospital who may be classified as having true cystic disease and one case in which there was a pedunculated pleural cyst. These patients have shown many of the bizarre clinical effects that may result from cystic disease, and certain unique features of diagnoses and treatment were employed.

CASE 1.—(See Fig. 1.) *Rupture of a balloon cyst with spontaneous pneumothorax in an infant.* N. D. (Reported by Croswell and Kings[8]), male infant, aged eighteen months when seen in the Chest Service in August, 1931. The child

was normal at birth and developed normally without respiratory symptoms until he suffered attacks of bronchopneumonia at five months and again at thirteen months. No unusual dyspnea was noticed with these infections. Fourteen weeks before admission, the child had another attack of respiratory infection with considerable dyspnea and wheezing, which suggested asthma. He had another sudden attack of acute dyspnea twelve weeks before admission, at which time a chest film was taken while the child was under the care of Dr. C. V. Croswell of Memphis, which showed the heart and mediastinum displaced into the right chest and great compression of the left lung. One or two liters of air were aspirated frequently from the left chest. Physical findings at the time of admission were those of huge pneumothorax on the left. X-ray and fluoroscopic examinations revealed bilateral, large, cystlike areas and apparently a pneumothorax pocket above the left leaf of the diaphragm, the movements of which were paradoxical. A needle inserted into the upper left chest gave a positive pressure reading of 20 cm. of water. Nine hundred c.c. of air were aspirated, which brought about prompt and striking relief of the patient's dyspnea, and the pressure decreased to 6 cm. of water. Lipiodol was injected into the cyst and films were taken in different positions which confirmed the impression of bilateral voluminous cysts and spontaneous pneumothorax. Dr. Croswell reported this case as unilateral cysts, but by moving the infant under the fluoroscope lipiodol could be seen to flow across the midline and outline a group of small cysts in the right chest in addition to the huge ones on the left side. Whether the cysts on the right side herniated through the mediastinum or originated on the right side could not be determined. Frequent aspirations of air were continued by Dr. Croswell during the following month but finally, after the aspiration of a small amount of serous fluid, the mediastinum returned to its normal position and subsequent aspirations of air became unnecessary. A recent communication from Dr. Croswell states that the child is clinically well and the x-ray film of the chest reveals nothing abnormal. It is the opinion of Dr. J. J. Singer that after the fluid formed, adherence of the pleura occurred obliterating the pleural space, thus preventing spontaneous pneumothorax which was the most important factor in causing the symptoms of pressure. A fibrosing process following inflammatory reaction probably occluded the bronchiolar communication to the air sacs and allowed the air therein to be absorbed.

CASE 2.—(See Fig. 2.) *Rupture of cyst causing pneumothorax in an infant with sarcoma of the lung.* S. F., this patient, a twenty-eight-month-old girl, was first admitted to the St. Louis Children's Hospital in January, 1933, when she had a cough, slight fever and dyspnea, which were out of proportion to the rest of the clinical picture. There was notable retraction of the costal margins on inspiration. Physical examination of the chest revealed nothing pathologic, except suppression of the breath sounds over the midportion of the right lung posteriorly. An x-ray film taken at that time showed some general haziness of both lung fields and in retrospect an area of rather nondescript mottling below and lateral to the right hilus region may be seen. She recovered quite completely from this respiratory infection, which was called influenza, but soon began having a slight nonproductive cough. In the two weeks preceding her second admission, which was May 24, 1933, she had been dyspneic but not cyanotic. The dyspnea was not paroxysmal. On admission, she was afebrile but had some cough, and there was a mild rhinopharyngitis. There was notable fullness of the right hemithorax, and the percussion note was hyperresonant over this side. The heart and mediastinum were displaced into the left side. Breath sounds were absent throughout the right chest, except over an area near the sternum anteriorly where there was amphoric breathing. An x-ray film showed a huge pneumothorax pocket compressing the right lung and crowding

the heart into the left chest. Above the inner third of the right leaf of the diaphragm, there were several rounded rarefied areas surrounded by zones of increased density and averaging 2 cm. in diameter. The lowest space seemed to contain a fluid level. Lipiodol introduced through a needle which was inserted through the space between the cricoid and thyroid cartilages failed to enter any of the cyst-like areas. A needle inserted into the right pleural space showed the pressure to be positive 6 cm. of water. Air seemed to refill the pleural space as fast as it was withdrawn, and when the infant coughed, the marked fluctuations in the pleural pressures indicated a very free communication of the pleural space with the bronchus. Tuberculin test was negative, and other routine laboratory tests were also negative.

The patient gradually became worse during the next months and died in September, 1933, nine months after she was first seen. During the intervening months, a mass had grown to fill the right side of the chest. At necropsy this mass was

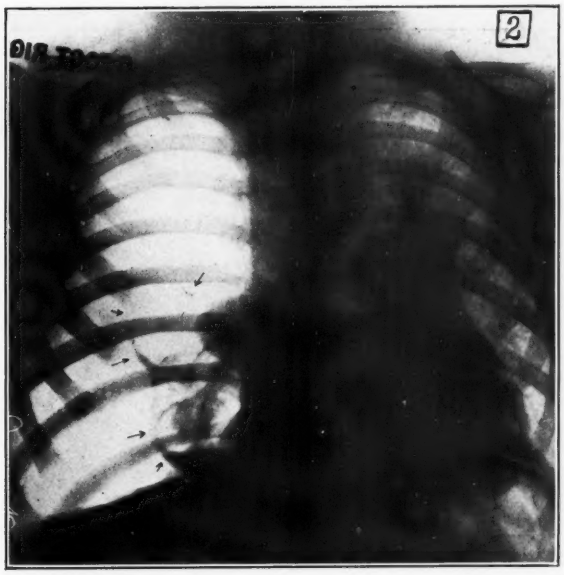

Fig. 2.

found to be a huge sarcomatous tumor. The probable course of events was that a slow growing sarcomatous tumor largely occluded a small bronchus; small cysts were formed behind the obstruction; further distention of one of the cysts caused it to rupture and a pneumothorax was produced. The tumor grew to fill the entire right hemithorax, compressing the lung tissue and the cysts beyond recognition.

CASE 3.—(See Fig. 3.) *Cysts in an infant with complicating pulmonary infections.* J. H., a one-year-old male infant, was perfectly well until he suffered an attack of bronchopneumonia five months before admission. He continued to have cough and sputum, with some fever, until admission to the St. Louis Children's Hospital on May 19, 1931. Physical examination revealed a chronically ill infant with marked clubbing of the fingers. There were râles of various types throughout both sides of the chest and physical signs suggesting an air pocket in the left apex. An x-ray film showed a large air pocket in the upper left chest. In differenti-

ating the etiology of the air pocket, tuberculous and pyogenic cavities were excluded on account of the size of the cavity, lack of the usual associated changes seen in the x-ray film, and the lack of the clinical syndrome of either disease. Solitary emphysematous blebs of this size do not occur in infants. An empyema cavity containing air would almost certainly contain a fluid level. The clinical picture, history, physical findings, and x-ray picture pointed to a congenital cyst with associated acquired bronchiectasis. Lipiodol filling was not done on account of a complicating bilateral mastoiditis and the general poor condition of the patient. A bilateral mastoidectomy was performed one month after admission and the child died the following day. At necropsy a large, smooth lined cyst, occupying the greater part of the upper left lobe, the wall of which was somewhat trabeculated, and no open bronchial communication was found. There was in addition extensive bilateral bronchiectasis with superimposed inflammatory changes. The alveoli in the atelectatic portion of the lung about the cyst were markedly compressed and

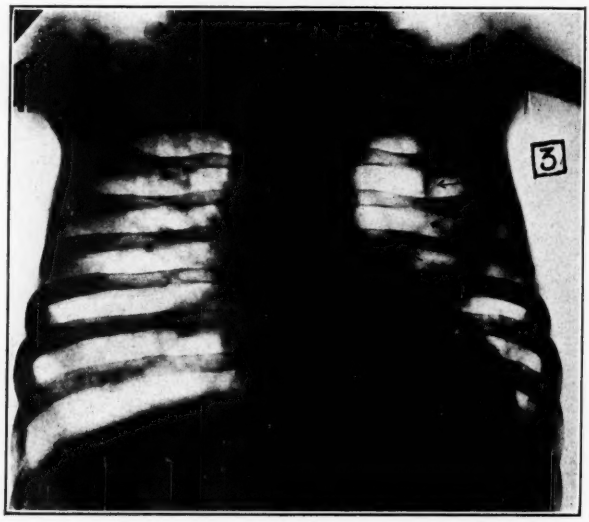

Fig. 3.

free from coal pigment. The bronchi were very irregular, and it was difficult to differentiate adequately between the various layers of the bronchial wall.

CASE 4.—(See Fig. 4.) *Multiple unilateral infected cysts simulating bronchiectasis.* J. S., a fourteen-year-old white girl, began having a chronic cough at the age of three months without history of foreign body, aspiration or acute respiratory infection. This cough had continued throughout her life without periods of acute illness and without fever. There was a slight amount of sputum for many years, but it increased in amount and became moderately foul within the six months before admission, and during this time there was considerable deterioration in her general health. She had slight hemoptyses and some night sweats shortly before admission. She vomited frequently and blood was seen in the vomitus on two occasions. Physical examination revealed a very poorly nourished, pallid girl with an offensive breath and moderate clubbing of the fingers. The percussion note was dull over most of the left chest and was hyperresonant over the right. The breath

sounds were tubular in character over the lower portion of the left chest and whispered voice was increased. There were râles of many kinds heard over the entire left chest and some over the right. There was a to-and-fro friction rub heard at the left base at one time. Expansion of the left chest was greatly limited. The heart was apparently normal but the blood pressure was only 90/60. There was also a pansinusitis and faucial and lingual tonsillitis. The sputum was foul and it settled with a frothy float. No tubercle bacilli or spirochetes were found. In spite of a negative Kahn reaction on the blood of the patient and both parents, congenital syphilis was strongly suspected on account of rhagades wrinkles about the mouth, suspicious Hutchinson-like teeth and peculiar pigment deposit in the retinas which was thought to be characteristic of syphilis. The usual laboratory data were all normal except a white blood count of 17,000 with a mildly infectious blood picture. X-ray film revealed enormous cystlike cavities throughout the left

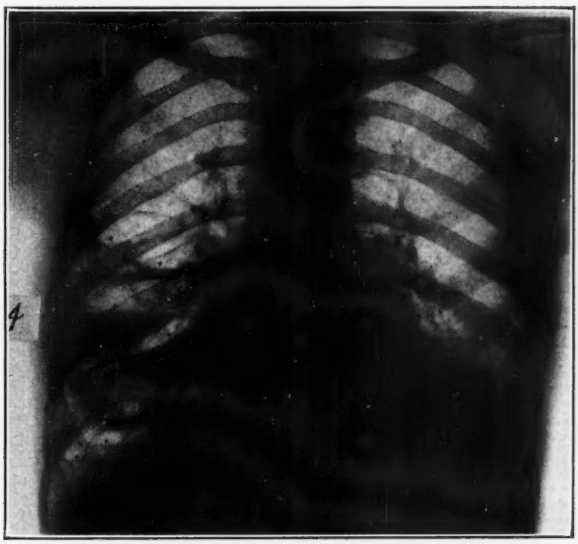

Fig. 4.

lung which are almost identical with those described by other authors as congenital cysts. Bronchoscopic drainage was instituted and was scheduled to be done at weekly intervals, but after the second drainage she went to her home, which was out of the city, and apparently developed an acute respiratory infection from which she died.

Case 5.—(See Fig. 5.) *Large cyst with fluid, infected with B. influenzae.* F. P., an eighteen-year-old white girl, was first seen in the Chest Service in August, 1929. Family history and past history were not relevant. Her illness began two years before with a cough that began insidiously without history of preceding respiratory infection or foreign body aspiration. Sputum increased in quantity rapidly after that time and became foul. She had occasional periods of acute illness with chills, fever and sweats. Physical examination revealed a well-developed and nourished girl, apparently not acutely ill. Expansion was limited over the left chest, and the breath sounds and whispered voice were of very high-pitched

quality over the lower left chest. Numerous râles were heard in both lower chests. There was no clubbing of fingers. Laboratory tests revealed no very significant findings. The sputum was greenish yellow and slightly malodorous. No tubercle bacilli or spirochetes were found after many examinations and guinea pig inoculation. Culture of pus obtained by aspiration through the chest wall gave a pure growth of the Pfeiffer influenza bacillus. Lipiodol given by aspiration method did not enter any of the cavities, but one cavity was filled with lipiodol at the time of a bronchoscopic examination. The air pressure in one of the main cavities was plus 4 cm. of water. Lipiodol injected through the chest wall into one of the cavities was soon coughed up by the patient. She ran a low-grade fluctuating

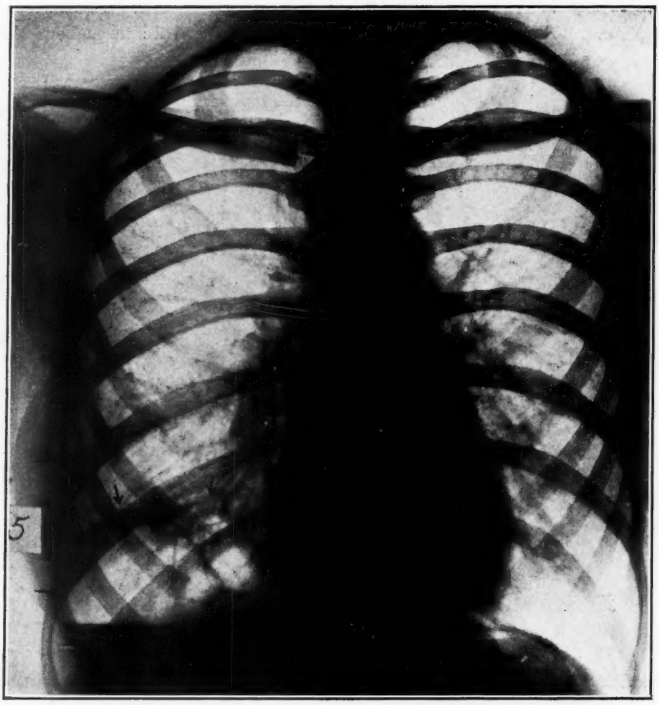

Fig. 5.

temperature. On September 17, 1929, Dr. Evarts A. Graham resected a portion of the right ninth rib and found a thickened cyst wall which he did not open at that time. On October 1, the cavity was opened by use of the actual cautery. This drainage stopped the sputum from being coughed up, but she continued to have a draining sinus, without fever, for three months. On January 1, 1930, Dr. Graham resected two more ribs and made the opening for drainage wider. He performed a phrenicectomy on February 17, 1930. In spite of this treatment, which allowed adequate drainage, the cavities did not decrease in size. In January, 1931, an attempt was made to reenter the cavity by posterior incision, and it was necessary to remove some regenerated bone and to cauterize lung tissue. A severe hemorrhage occurred at this operation which required packing the wound. Five days later

when the packing was removed a severe hemorrhage occurred from which the patient died in a few minutes. A section of the wall of the cystic cavity showed a definite epithelial lining with flattened cells and inflammatory reaction throughout the wall.

CASE 6.—(See Fig. 6.) *Multilocular cyst infected with B. influenzae.* A. M., a twenty-five-year-old garage mechanic, was first seen in the Chest Service in 1931. At that time he had a cough productive of foul sputum which had been present for seven years. He had pneumonia as a child, but this cleared up after three or four weeks. He had a chancre in 1921, with a positive Wassermann and received a little treatment in 1928. The Wassermann reaction was negative on several recent

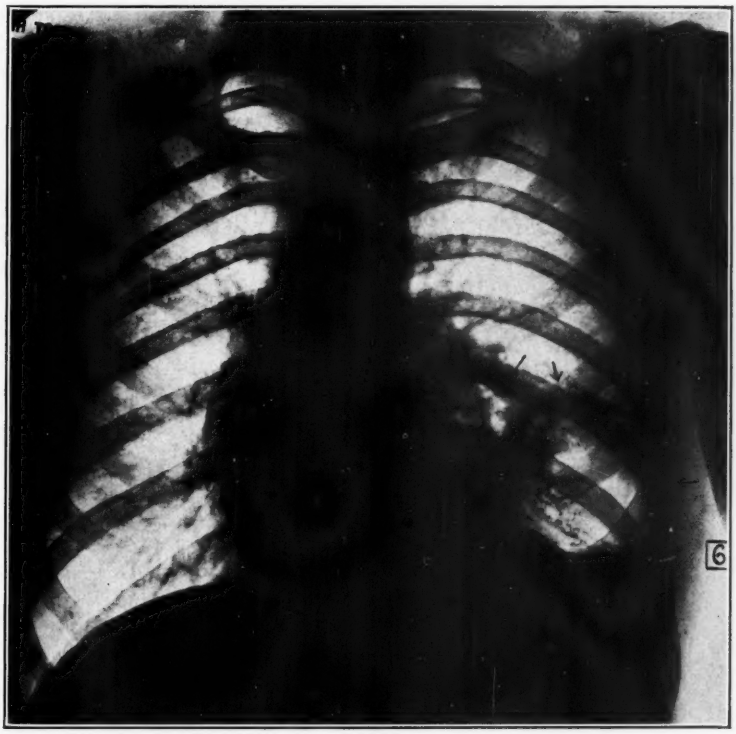

Fig. 6.

tests. His illness began in September, 1925, with chills, fever and severe pleurisy pain on the left side. A productive cough followed, but he returned to work in six weeks. Cough continued without purulent sputum until August, 1928, at which time he suddenly coughed up a pint and a half of thick malodorous pus. Two years later he again coughed up a quantity of pus. During the year before admission, he practiced postural drainage with success. Three hundred c.c. of pus were obtained by postural change at time of first admission. He was well nourished and developed. There was no clubbing of the fingers, nor any respiratory distress. Over the left base there was dullness, absence of breath sounds, and a few râles. The laboratory data were negative, except for a 17,000 white blood count with a

mild infectious blood picture. No tubercle bacilli or spirochetes were seen in many examinations of the sputum. Pus obtained by aspiration through the chest wall and the sputum both gave pure cultures of Pfeiffer influenza bacillus. On April 8, 1931, Dr. Evarts Graham resected a portion of the eighth rib overlying the cavity and inserted a tube for drainage. A thoracoscope was introduced through the incised wound, and a multiloculated cavity with glistening lining and bronchial fistulas was seen. The sinus continued to drain during the next five months, and Dr. Graham performed a left phrenicectomy on October 5, 1931, after which the diaphragm was immobile but its height was not raised appreciably. On November 6, 1931, Dr. Graham removed the five ribs above the sinus from the transverse process to the posterior

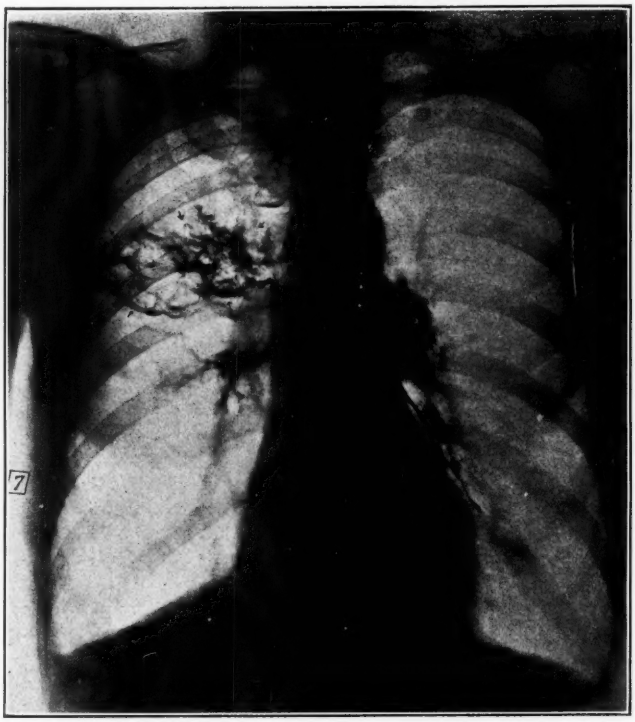

Fig. 7.

axillary line in an effort to collapse the cavity. Unfortunately the walls of the cavity were so rigid that they failed to collapse at all and pushed the mediastinum toward the opposite side before them. The patient still has a sinus from which there is only very slight drainage and a bronchial fistula communicates with the cyst. He refuses to allow an extirpation of the cysts.

CASE 7.—*Cystic disease (?) associated with bronchiectases.* E. T., a thirty-eight-year-old man, was free from respiratory symptoms until he was struck by a street car eighteen years previously. He was in bed for seven months thereafter, during which time he had cough and much sputum. He then was sufficiently well to resume work which he continued for one year. He then began having frequent pulmonary

hemorrhages which lasted over a period of two years. During the ten years before admission to Barnes Hospital, he had repeated attacks of acute pulmonary infection and a chronic cough with some purulent material which was not particularly foul. Physical examination revealed general diminished breathing over the right chest and many moist râles. He also had bilateral maxillary sinusitis. Lipiodol injection revealed huge multiple cystlike cavities in the upper portion of the right lung which were not unlike those reported by other authors as congenital cystic disease.

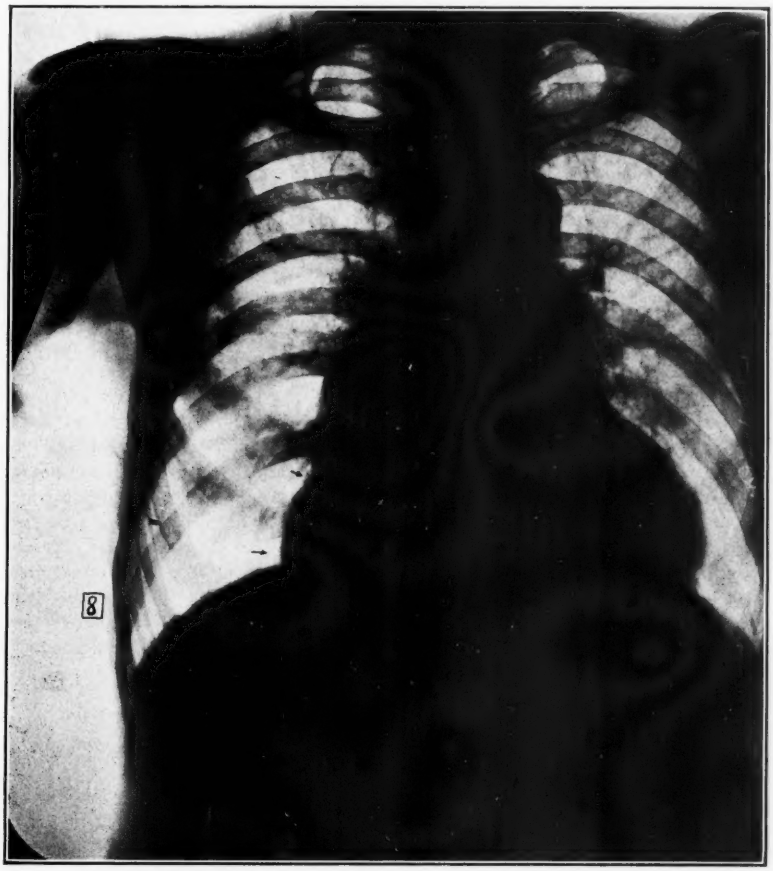

Fig. 8.

In addition to the large cystic cavities, there were cylindrical sacculations at the base of the right lung, which had the characteristics of acquired bronchiectasis. The history and the morphologic characteristics, though far from conclusive, suggest that the cystic changes in the upper portion of the lung were congenital and that an acquired bronchiectasis had secondarily been added to complicate the picture.

CASE 8.—(See Fig. 7.) *Emphysema with unilateral cystlike areas in upper lobe.* R. G., a forty-four-year-old negro, who had mild recurrent attacks of coughing and

wheezing, which he called asthma, for eighteen years before he was admitted to Barnes Hospital in November, 1931. He never required any specific treatment for his respiratory ailment. His complaints at time of admission were rapid loss of weight and abdominal distress. Examinations revealed a markedly emphysematous chest with dullness at the right apex and hyperresonance elsewhere. The breath sounds were amphoric beneath the right clavicle, and there were some postcough râles. X-ray examination revealed a cluster of cystlike cavities at the right apex without parenchymal infiltration. These filled readily with lipiodol and seemed to be in the midportion of the lung. The position of the cysts and the ready filling with lipiodol more or less excluded the possibility that these were emphysematous blebs. His sputum was very scanty, but numerous searches for tubercle bacilli were of no avail. He had no fever and had never had symptoms of tuberculosis. Some time later a tumor was felt in the right lower quadrant which, on exploration, was found to be an inoperable carcinoma of the cecum. He left the hospital, and at the time of his death autopsy was not possible.

CASE 9.—(See Fig. 8.) *Pedunculated cyst of the pleura.* J. R., a sixty-six-year-old coal miner, came to the hospital in April, 1933, on account of loss of weight, vomiting, and dyspnea over a period of twelve months. He had had no chest symptoms at any time in his life. Examination revealed a man with a markedly emphysematous chest which prevented satisfactory examination. There were some râles at both bases, but no physical signs of a tumor in the chest were elicited. A huge abdominal mass was felt and was thought to be carcinoma. Patient rapidly lost ground and died on May 2, 1933, five days after admission to the hospital. An x-ray film taken in search for malignancy of the lung revealed a shadow of great increase in density extending out beyond the right border of the heart, which suggested a wide and tortuous descending aorta or an atelectatic lower right lobe of the lung. No further procedure was employed to clarify the diagnosis of this mass because the patient's condition was very critical. At autopsy a large cyst containing about 200 c.c. of brown turbid serous fluid was found lying along the right border of the heart and suspended by a pedicle to the pleura over the pericardium. There was no evidence that this was an echinococcus cyst. A fold of pleura covered the cyst wall. Microscopic section of the wall showed a very thin epithelial covering which was continuous with the pleura. Beneath the epithelial cells there was loose connective tissue and no epithelial lining of the interior of the cyst. The abdominal mass proved to be carcinoma of the stomach.

DISCUSSION

From a consideration of the literature and study of cases, it appears that a large proportion of the cysts may remain asymptomatic throughout the life of the individual, and that the presence of cysts is usually called to the attention of clinicians only when some accident occurs, such as rupture or infection.

In spite of the pathologic confusion and unsettled theories of formation, the clinical features of lung cysts, though varied, fall roughly into rather definite groups. The variations in microscopic pathology have as yet no clinical correlations, but there are very definite syndromes which accompany certain gross pathologic changes and which are often determined by mechanical and accidental factors. The strength of the wall, the presence or absence of a bronchial communication, or of ball-

valve mechanism at the bronchiolar orifice, the anatomic relation of the cyst to other organs, the presence or absence of fluid in the cyst, or of infection determine the respective clinical pictures.

Anspach and Wolman[3] have suggested a classification of lung cysts. It would be difficult to place all of our cases in their classification which is based on "postnatal behavior of the cysts." A satisfactory clinical classification cannot be made until more cases have been clinically studied.

Cysts in infants necessarily have thin walls, regardless of their origin. Elastic tissue is said not to appear in the lung until about the second month of life. If these cysts contain air, they must communicate with a bronchus either permanently or intermittently; otherwise, air would be absorbed and the cyst would collapse. If the ball-valve mechanism occurs at the point of bronchial communication, air will be drawn into the cyst on inspiration and trapped during expiration. There is always very positive pressure in this type of cyst. The degree to which the cyst will expand depends on the strength of the wall; and if it expands to fill one hemithorax, its effect in causing compression on the other lung depends on the mobility of the mediastinum. It is thought that if a rapidly expanding cyst originates in the parenchyma of the lung it is likely to cause rupture of the lung tissue and produce a pneumothorax.

The cyst wall itself may not be sufficiently strong to stand rapid inflation and may rupture. Many of the cases which have had a rapidly expanding cyst or pneumothorax have died after one or more attacks of great respiratory distress. Vollmer[9] aspirated air from his patient, who recovered. Our first case survived many attacks and was aspirated many times. The patient is now clinically well.

If no bronchial communication is present, or if the communication remains patent, there is no opportunity for the production of a rapidly expanding cyst because the air cannot be trapped. Probably, if this accident does not occur in early infancy, the wall of the cyst becomes sufficiently strong to resist stretching. The patient in our first case no longer has desperate attacks of dyspnea like those that threatened his life during his second year. Debre and Blinder[10] reported the case of a boy of seventeen years with a voluminous air cyst, who had desperate attacks of dyspnea in early childhood, but in spite of persistent spontaneous pneumothorax is now clinically well. It seems quite possible that a cyst with a rigid wall may remain inflated with gas over a great period of time in the absence of a free communication with a bronchus. The gas within the cyst probably comes into equilibrium with the blood gases. Although there is some tendency to obliterate the air space by absorption of a part of the gas, the negative pressure created is not sufficient to collapse the wall. Certainly, pneumothorax pockets may persist in the chest for months or years without decreasing in size or

filling with fluid. Several air cysts have been found to have no demonstrable bronchial communication at autopsy. Our third case was such a type. This condition will probably not be found in infants because the cyst wall is too flexible.

Infants and young children with cystic disease are apparently easily susceptible to associated pulmonary infection. In many of the reported cases the patients have died of pneumonitis or bronchopneumonia. In our third case the patient was first seen by a physician on account of pneumonia.

Infection in certain types of cysts is almost inevitable and is possibly due to inadequate drainage of cysts which communicate with bronchi. It may be of low grade with minimal symptoms or be very severe. It will be noted that in two of our cases, pure cultures of the Pfeiffer influenza bacillus were obtained. This finding has also been made in patients of Siems,[11] Clairmont,[12] Eloesser,[2] and Sauerbruch.[13] Mancerelli's[14] patient died at eighty without infection in the huge cyst which was present, and Pollock and Marvin,[15] Siems,[11] Eloesser[2] and Møller[16] have seen patients over forty years old with cysts that apparently were not infected. There was apparently no infection in the cysts of our eighth case, a man of forty-four years, and the pleural cyst in our ninth case was not infected at the time of the patient's death at sixty-six.

Symptoms may be due simply to pressure of the cyst. Chest pain was the first symptom noted in several of the reported cases. Cough, apparently due to simple pressure on a bronchus, may be the only symptom. A cyst has been known to occlude a main bronchus by pressure. A cyst may cause repeated bleeding, which, along with the cough and pulmonary cavities, constitutes the usual syndrome of chronic fibroid tuberculosis.

DIAGNOSIS

The history and physical examination of the individual case seldom lend important aid in the diagnosis of cystic disease. Information gained from these sources varies so greatly that it is often misleading. Although x-ray examination offers the most reliable information in most cases, it has definite limitations. Møller[16] describes the typical picture of multiple cysts as follows: "There is a peculiar disposition of the cavities in relation to one another, irregularly arranged, each one sharply delimited and separated from the others by a fine network of consolidation without any infiltration or pulmonary tissue between." The difference between tuberculous cavities, cavities caused by pyogenic infection and true cysts is determined chiefly by the thinness of the walls of the latter, which are impressed by any solid structure with which they come in contact and by each other, and by the absence of associated changes usually seen in the former conditions.

Frequently the instillation of lipiodol by the supraglottal route, or by direct injection of the oil into a cyst through the chest wall previous to taking the x-ray film, will show the outline, extent, and communications of cysts not otherwise discernible. The cystic cavities may at times be definitely located, the contents examined, and the relationships determined by bronchoscopic examination. Direct operative exploration of a suspected cyst is the one absolute method of diagnosis. When a cyst is explored, a biopsy of the wall should be taken.

Many of the cases, reported as congenital cystic disease, are probably not unlike those recorded by other authors as congenital or acquired bronchiectasis. When multiple cysts become infected, they show the complete clinical picture usually seen in bronchiectasis. The differential points between cysts and certain forms of bronchiectasis are not well defined, but the former are usually larger, more nearly spherical and more discrete. Demonstrable bronchial communications of a true cyst are sometimes absent but are always easily demonstrable in bronchiectasis.

Single or multilocular cysts which become infected simulate acute or chronic empyema or lung abscess. Operations for supposed empyema have been responsible for the diagnosis in several cases of lung cysts. Krampf,[17] Neuhoff,[18] Eloesser,[2] and Graham (two of our cases) have operated on cysts with previous diagnosis of empyema. The finding of a well-defined wall about the cavity with epithelial lining and other characteristics of some portion of the bronchial tree confirms the diagnosis of cyst.

Solitary cysts containing fluid are a most difficult diagnostic problem. If there is air above the fluid, a fluid level is obtained and the picture may be almost identical with that of a lung abscess, tuberculous cavity, or empyema with bronchial fistula. Recourse to history of the case, process of exclusion, and operative exploration are the only means of differentiating cysts from such conditions as the above and from many other tumorlike shadows seen in the x-ray film caused by retrosternal struma, diverticulum of the esophagus, gravitation abscess from caries of a rib or gland, aortic aneurysm, benign and malignant tumors, and last, false cysts—cystic degeneration in neoplastic tissue as in dermoid cysts and malignant growths and cystic degeneration following inflammatory reactions.

A huge air cyst can hardly be differentiated from pneumothorax without the x-ray picture, although one may suspect the condition from a history of repeated attacks or respiratory distress and cyanosis. The presence of a pneumothorax, either spontaneous or induced (see Pollock's case[15]) may allow the wall of cyst to be shown in an x-ray film. The characteristic hilus stump, which is always present with complete pneumothorax, is not seen in a voluminous cyst.

PROGNOSIS AND TREATMENT

The relatively high mortality in infants and young children with cystic disease is due chiefly to the fact that the reserve of the respiratory mechanism is not great. They cannot compensate for changes in pressure and position caused by large cysts, and their reserve becomes very low when there is an associated pulmonary infection. The outlook is not necessarily bad even in infants. If fatal accident is prevented by well-timed aspiration of air, the air of the cysts may eventually be absorbed and a clinical cure results. In our first case the patient is now apparently clinically well. Vollmer aspirated a cyst and reported a clinical cure. If death does not result at the time of the rupture of a cyst, the child may live indefinitely with a pneumothorax. Debre and Blinder's[10] patient apparently had a pneumothorax for many years and was not debilitated. There is not sufficient available information from similar cases to prophesy what harm may result from a persistent pneumothorax. If the branch of the bronchus which communicates with the cyst can be stenosed, the portion of the lung containing the cyst will probably collapse and the remainer of the lung will reinflate. If infection occurs in the cyst, the possibility of a permanent cure is greatly diminished.

The problem in multiple cysts which are infected is similar to that of severe bronchiectasis. The conservative measures, namely, postural drainage, vaccine administration, bronchoscopic drainage, etc., have been employed many times without gratifying results. Phrenic exairesis has not been reported to be of value in obliterating cysts. Dr. E. A. Graham performed phrenicectomy on two of our cases. Artificial pneumothorax has been used as a diagnostic measure in order to outline a cyst wall. This procedure will probably not be a valuable therapeutic method because the cysts are displaced by the air but not obliterated. Eloesser[2] performed a lobectomy, removing a group of infected cysts in a young woman with complete cure. Our fourth and fifth patients died after prolonged debilitating illnesses during which time no treatment was of value. Patients with multiple infected cysts who have suffered little deterioration in health have been reported by Gibson,[19] Eloesser,[2] Møller[16] and others.

Infected solitary cysts lend themselves to therapy more readily than multiple cysts. Drainage by rib resection has been instituted frequently with great improvement in the patient's general condition but permanent fistulas have always resulted because the cyst is not obliterated. Extirpation of solitary cysts has been reported by Clairmont,[12] Melschoir,[20] Krampf,[17] Sauerbruch,[13] Møller,[16] Ehlers[21] and Harrington,[22] with five apparent cures and four deaths directly attributed to the operation. Sauerbruch[13] combined thoracoplasty with extirpation of the

cysts in one case. Dr. E. A. Graham has performed a partial thoracoplasty in two of our cases without materially affecting the size of the rigid cysts.

A therapeutic suggestion has been made by Dr. W. E. Adams.[23] He believes that if all the cysts in a given case are in relation to one division of a bronchus, stenosis of this bronchus will cause collapse of the portion of the lung containing the cyst and the air in the cyst should eventually be absorbed. Stenosis of bronchi in man has been done by Adams, who applies 35 per cent silver nitrate through a bronchoscope to the bronchial mucosa. Adams has also suggested that silver nitrate could be injected into cysts in an effort to destroy the lining epithelium and give better opportunity for obliteration of the cavity.

Upper respiratory infections are a serious menace to patients with cystic disease. Apparently, in some instances a "vicious circle" is set up between infected nasal sinuses and cysts. Measures should be taken in every case to prevent, or if possible, eradicate all chronic upper respiratory infections.

CONCLUSIONS

Cystic disease of the lung causes clinical symptoms of widest variety. It may simulate clinically and roentgenologically pneumothorax, tuberculosis, bronchiectasis, lung abscess, empyema, emphysema, and other chronic lung diseases. The diagnosis is difficult in many instances and will probably not be made frequently unless the condition is kept in mind. Recourse to all diagnostic methods is necessary to make the diagnosis of cystic disease in some cases. History, physical examination, x-ray examination with iodized oil, diagnostic pneumothorax and operative exploration, all give important information but each has its limitations. The treatment in a given case depends on the symptoms produced, the number of cysts present, their size, the nature of the contents of the cysts, and associated pulmonary and upper respiratory infection. Treatment instituted with knowledge concerning the physiologic and pathologic background of the cysts may in many instances be eminently successful. If the cysts persist for years with infection, successful therapy depends on radical surgical procedures.

A cursory review of the 172 cases which have been reported in the available literature has been made.

Eight cases of cystic disease and one pedunculated cyst of the pleura which have been seen in Barnes Hospital in the past four years are presented.

Prognosis in the future may be greatly aided by observation and reports of recognized cases over a period of years.

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Department of Reviews and Abstracts

CONDUCTED BY DUFF S. ALLEN, M.D., ASSOCIATE EDITOR

Selected Abstracts

Roberts, J. E. H, and Nelson, H. P.: Pulmonary Lobectomy. Brit. J. Surg. **21**: 277, 1933.

The authors report 8 cases of unilateral bronchiectasis and 2 cases of carcinoma of the lung treated by pulmonary lobectomy.

The first portion of the article is given over to a description of the technic, which will not be described here, it being essentially Shenstone and Janes' modification of Brunns' one stage lobectomy.

Of the 10 patients treated, 1 died ten days following the operation from a cerebral abscess; 6 are healed and free from symptoms; 2 are improved and are able to work. One patient died three months after operation of influenzal pneumonia.

Hemorrhage on the operative day occurred twice. In one case the bleeding was from the pulmonary ligament and the chest had to be reopened. In the other case although there was a moderate amount of blood loss, the hemorrhage was controlled by other means. In the third case 1,500 c.c. of blood were lost on the fourteenth day following the operation. The hemorrhage stopped, however, and it was not necessary to open up the chest. The authors feel that this hemorrhage was undoubtedly from the pedicle and expressed the belief that it may have been due to failure to bury the bronchial stump in the inferior surface of the upper lobe, a procedure which had been carried out in the other nine cases. Small basal empyemas developed in three cases, and a subphrenic abscess occurred in one case. Although three large and two small bronchial fistulas developed, they all closed spontaneously.

In those cases in which the lower lobe was removed, a descent of the upper lobe and a rise of the diaphragm tended to obliterate the pleural space. In the cases in which an upper or middle lobe was removed, expansion of the remaining lung tissue tended to obliterate the space left by the removed lobe.

W. M. Tuttle.

Jones, Robert M.: The Surgical Treatment of Bronchiectasis. Brit. J. Surg. **21**: 257, 1933.

The author reviews briefly the literature on the treatment of bronchiectasis and arrived at the conclusion that lobectomy is its most logical treatment. It is pointed out, however, that in the past the high mortality rate following lobectomy has made the use of this operation prohibitive.

Sixteen cases of bronchiectasis treated by lobectomy using a modification of Brunns' method are reported. Of these, six patients were cured (37.5 per cent), three were improved (18.7 per cent), two were unimproved (12.5 per cent), and five died (31.2 per cent). One other case not included in the sixteen previously mentioned was treated by the two stage method and died of bronchopneumonia on the fifth postoperative day.

The causes of death in the five cases were: 2 patients died of bronchopneumonia on the fifth and sixth postoperative days, respectively; 1 patient died of bronchopneumonia, empyema and suppurative pericarditis thirty-eight days after lobectomy, and in this case there was a rather extensive bronchiectasis throughout the remaining lobe which did not fill at the time of the preoperative lipiodol injection. The fourth patient died after a secondary operation to close a bronchial fistula from hemorrhage from the internal mammary artery eight months after lobectomy. The fifth patient died of a brain abscess fifty-two days after lobectomy.

Of the sixteen cases reported, 6 patients developed bronchial fistulas, 3 of which closed spontaneously, 1 required subsequent surgery to close it, and in 2 cases the patients died. Four of the sixteen patients developed empyemas.

The author feels that only those patients who have a unilateral bronchiectasis, who have been afebrile and free from attacks of pneumonitis for some time, should be subjected to lobectomy. After a careful study of his material he came to the conclusion that 40 per cent of his mortality was due to failure to observe these facts.

W. M. Tuttle.

Zannelli, Carlo: Illustration of a Case of Double Phrenic on Both Sides. (Illustrazione di un case di doppio frenico. bilaterale) Lotta contro la tuberc. **4**: 979, 1933.

The author studies the anomalies of the phrenic nerves, of both origin and course, and describes the following case: In a right-sided pulmonary tuberculosis in which pneumothorax was unsuccessful because of adhesions, right phrenicectomy was performed. The diaphragm rose and became immobile. The operation was followed by clinical improvement which lasted two months. At that time tuber-

culous spread appeared in the middle field of the left lung, and at the same time the right diaphragm was found to be perfectly mobile again. Pneumothorax was induced in the left side followed by phrenicectomy on the same side. During the operation it was found that the phrenic was represented by two nervous branches of equal size, both situated in the anterior surface of the left scalenus anticus, which were avulsed. After a short time the right tuberculous lesion progressed, and a second right phrenicectomy was deemed advisable. At the operation a second phrenic trunk was discovered on the posterior surface of the scalenus anticus, which was avulsed. Both diaphragms became permanently paralyzed. The author reports that this was the only case of bilateral double phrenic in 500 phrenicectomies.

Pol. N. Coryllos.

Bernard, Leon, and Pleissier, and Silbermann: The Roentgenkymography in Phthsiology. Presses méd. **11**: 2053, 1933.

Roentgenkymography, also called radiokygraphy, is a method devised in 1912 by Gött and Rosenberg, and used in the study of the heart by Strumpf, Delhern, Thoyer-Rosat and others. It consists of sliding between the patient and the photographic film a metallic grill composed of plates of lead 14 mm. in width separated by intervals of 5 mm. This grill is displaced slowly during the exposure, which lasts six seconds for pulmonary kymography, i.e., about two respirations. The radiographic film thus taken presents vertical lines and between them the contour of the ribs, diaphragm, lungs and heart in the form of a spiked line. By studying the direction and height of these spikes it is easy to determine with precision whether ribs, lungs and diaphragm have moved or not during the exposure and to what degree.

In studying the chest of 24 tuberculous patients the authors were able to investigate the degree of mobility of tuberculous cavities following pneumothorax and phrenicectomy. They found that it was possible by this procedure to determine in pneumothorax the "optimum" pressure which insures the maximum of immobilization of the lung. They corroborated the opinion of Meerson that these pressures vary in each individual case, that they cannot be regulated by general rules, and that whereas in the majority of cases negative pressure suffices in others positive pressure is necessary.

More important are their findings in phrenicectomy. These findings did not confirm either the general opinion that the paralyzed diaphragm remains immobile or that the rising of the diaphragm means immobilization of the corresponding lung. In fact in all their cases paradoxical movements (Keinbock) were present, the extent of which was equal to the movements of the healthy diaphragm, with the only

difference that they were of opposite direction. At any rate this procedure, still under study, seems to constitute an interesting method of investigation in pulmonary tuberculosis.

Pol. N. Coryllos.

Yamada, S., and Hatta, T.: The Compensation Capacity of the Lung. Ztschr. f. d. ges. exper. Med. **90**: 339, 1933.

In rabbits the branches of the pulmonary artery were successively ligated. After ligation of the branches of the left pulmonary artery, the pressure in the carotid arteries after a temporary drop became normal; likewise the pressures in the trunk of the pulmonary artery and the right ventricle, after a temporary rise, returned to normal. Respiratory rate and depth changed. The O_2 content of the arterial blood did not change.

Twenty weeks after operation no changes could be found in the respective weights of the right and the left ventricles as compared to those of control animals. On the contrary, ligature of the right branch of the pulmonary artery produces permanent lowering of the pressure in the carotid arteries and a permanent rise in the pulmonary artery and right ventricles. Respirations increase in number and decrease in depth. O_2 content of the blood is about 20 per cent lower, CO_2 is from 10 to 15 per cent higher than normal. The weight of the right heart was increased by 10 per cent.

Right-sided pneumothorax in rabbits acted in the same way, that is, there was a rise of pressure in the pulmonary artery as the intrapleural pressure increased. According to Hatta the differences of the volumes of the right and left heart (54 per cent and 46 per cent) were responsible for the differences in the respective results of the ligatures of the right and left branches of the pulmonary artery. Contrary to the conception of Sauerbruch and Bruns, Yamada and Hatta believe that the resistance in the vessels of the collapsed lung is increased.

Pol. N. Coryllos.

Behrens, W.: The Operation of "Plombage" (Apicolysis) in Pulmonary Tuberculosis. Tubercle **15**: 97, 1933.

The indications for apicolysis with plombe are: first, small apical cavities with fibrotic changes with positive sputum which have resisted a prolonged rest treatment; in such cases the operation may be bilateral. Phrenicectomy, pneumothorax or thoracoplasty in the contralateral side are not contraindications for apicolysis; second, in cases in which previous thoracoplasty has not produced closure of the cavities.

Behrens prefers the posterior approach and operates under local anesthesia. He has no personal experience with the axillary approach.

Tearing of the pleura, lung tissue and especially of the walls of a cavity should be carefully avoided. As postoperative complications the author mentions only mild irritation of the surrounding tissues, which is much less than that produced with Vivocol. In young cavities complete collapse and linear scar follow, whereas older cavities with thickened walls collapse only partially.

Of the author's 28 cases 22 were greatly improved; sputum became negative and the patients were able to perform regular work; 4 were able to perform only partial work, and 2 died. In 7 cases, less favorable than the previous ones, one was improved, 4 were unimproved, and 2 died. Of the 3 bilateral apicolysis, 2 improved and one died.

Pol. N. Coryllos.

Löffler, Leonard: Experimental Pulmonary Abscess. Remarks on Embolism. Deutsche Ztschr. f. Chir. **242**: 570, 1934.

In a series of experiments performed on dogs, pulmonary embolism was first produced by means of sterile paraffin introduced into the jugular; the bronchus corresponding to the area of infection was then obstructed with a sterile foreign body. Very often, following this double procedure chronic abscesses have developed, similar to human putrid abscesses by their chronicity, the necrosis of the surrounding parenchyma, their prolonged suppuration and their complications. Vascular embolism alone, like bronchial obstruction alone, was equally insufficient for the production of chronic abscesses.

The clinical aspects varied from benign solitary well-delimited abscesses to multiple abscesses or even diffuse suppuration of a whole lobe.

Pol. N. Coryllos.

Rose, F.: Purulent Tuberculous Pleurises. (Russian.) Nov. Chir. Arch. **28**: 387, 1933.

Tuberculous empyema develops most frequently following pneumothorax. Of 83 cases of tuberculous empyema, 64 had followed artificial pneumothorax, 13 spontaneous pneumothorax, 2 thoracoplasty and only 4 developed in cases in which no pneumothorax had been performed. In all, tubercle bacilli were found in the fluid. In the treatment of these cases two methods are to be considered: conservative and surgical. The first consists in evacuating the fluid and washing the pleural cavity, by means of two puncture needles with from 5 to 10 liters of normal sodium chloride solution until the fluid runs clear. This procedure lasts from one to one and one-half hours and was repeated in from five- to seven-day intervals, 15 or 16 times in all. When the pleural fluid remained purulent after that time and no cure or marked improvement was obtained, the case was considered unfit for conservative treatment. Twenty-four cases were treated by

this procedure: 19 were pure tuberculous empyemas, of which 7 were cured, 7 improved, and 5 were unchanged. Five were tuberculous empyema with mixed infection, all of which failed.

Surgical treatment consisted of paravertebral thoracoplasty, and with even better results in the complete costal resection of Rose. The latter is performed in three stages, with two or three weeks between stages. In cases with severe toxic symptoms the pleural cavity was drained at the first stage.

The results obtained by paravertebral thoracoplasty of Sauerbruch-Brunner type were not favorable. With Rose's operation without previous drainage on 3 cases, one patient was cured, one died with amyloid degeneration, and one was drained later. Better results were obtained by Rose's operation with drainage: of 9 cases 6 patients were cured, in 2 suppurating sinuses persisted, one died.

Tuberculous empyemas with infection cannot be saved by conservative treatment. Rose's operation with primary drainage gives the best results: of 33 patients operated on by the procedure 11 were cured, 12 decidedly improved, 3 moderately improved, 7 died. Two were operated by the Schede's procedure: one was cured, one died. Of all these cases one-third were cured, one-third were able to work although with suppurating sinuses, one-third died.

Pol. N. Coryllos.